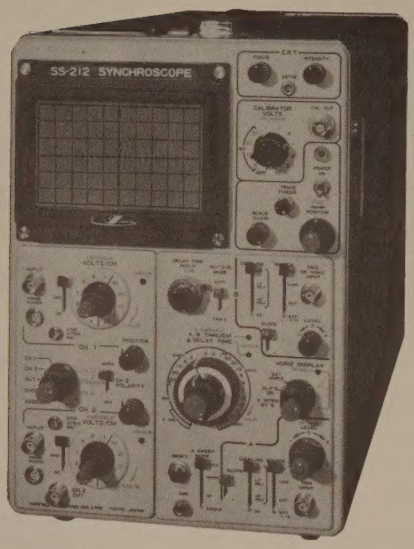
664

INSTRUCTION MANUAL

SYNCHROSCOPE
SS-212

IWATSU ELECTRIC CO., LTD.
TOKYO, JAPAN



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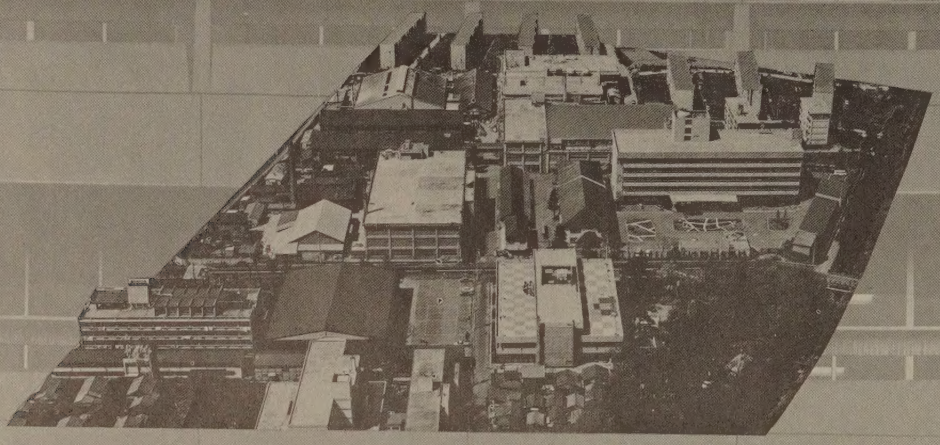
135321~ Apr. 1971

Thank you for your purchasing IWATSU Synchroscope SS—212



The IWATSU SS–212 SYNCHROSCOPE is the newest product of IWATSU, the pioneer of synchroscopes. The ample experience and inexhaustible originality of IWATSU's engineers in this field made the development and production of this extraordinary high performance SYNCHROSCOPE possible.

As a result of their unique design, the quality of IWATSU's electronic instruments are highly warranted. Transformers and rotary switches are designed for electronic instrument use, and then manufactured in our factory under strict quality control. These components are warranted for the life of the instrument.

Semiconductors and other precise components are selected from a wide range of top-ranking foreign and domestic products, and only those which pass our severe tests are employed in our instrument.

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General

The SS–212 SYNCHROSCOPE is a wide bandwidth, all purpose synchroscope. Its bandwidth is from DC to 200 MHz.

The electronically switched dual-trace vertical deflection system features this wide bandwidth (200 MHz) even in high sensitivity ranges.

The horizontal deflection system contains a trigger circuit which can be triggered from DC to 200 MHz, and a delayed sweep circuit which allows expanded observation of any desired point on the displayed waveform.

The 5-inch square CRT with an internally marked graticule provides a 60 mm (Y axis) x 100 mm (X axis) parallax-free display. Extremely high stability is obtained by the use of a completely solid-state circuit. Measurements can be performed only 15 seconds after switching the power on.

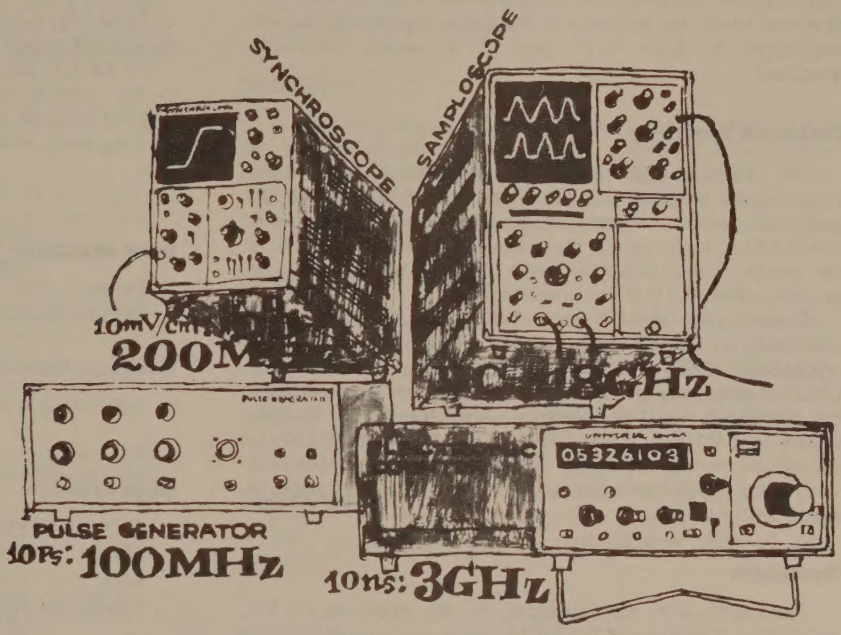
Composition

The instrument is composed of the following articles.

Accessories

Coaxial Cable (BB–500)	1
Jumper Cable (TT-400-G)	1
Probe	2sets
2000 Earth Lead	1
Post Adapter (C)	2
Hexagonal Wrench (4 mm)	1
Hexagonal Wrench (3 mm)	1
Hexagonal Wrench (No.2–UNC)	1
Screw Driver	1
Dust Cover	1
Accessory Bag	1
Fuse	2
Polarized Filter	1
Instruction Manual	1
Inspection Report	1

CHAPTER 1. CHARACTERISTICS



In this chapter, the electrical and environmental conditions necessary to assure accurate measurements are briefly described. Refer to "Description of Panel Controls" in Chapter 2, for information on the knobs and connectors mentioned in this chapter.

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▶Vertical Deflection System

The pre-amplifier of the vertical deflection system comprises an electronically switched dual-trace system. The characteristics and accuracy in the following description are applicable to both CH 1 and CH 2, unless otherwise specified.

Deflection Sensitivity

Ten (10) calibrated ranges from 5 mV/cm to 5 V/cm are provided to ensure an optimum deflection sensitivity for any measurement. Variable attenuation is possible with the VARIABLE knob which decreases the sensitivity by 1/2.5 (or more) of the calibrated value. Thus a low sensitivity of approximately 12.5 V/cm is available.

The accuracy of the highest sensitivity, 5 mV/cm, can be calibrated to 0 % tolerance with the internal 5 mV GAIN adjustments R56A/R56B (R56A for CH 1, and R56B for CH 2). The accuracy of any range above 10 mV/cm can also be calibrated to 0 % tolerance with the 10 mV GAIN adjustment R108 and the GAIN ADJ adjustment R219. It should be noted, however, when one range is calibrated with these potentiometers, the accuracy of other ranges is set to withing +3 %.

Bandwidth

The bandwidth corresponding to the positions of the AC-GND-DC and the VOLTS/CM switch are:

DC	5 mV position	DC to 150 MHz	(within −3dB)
	10 mV positions	DC to 200 MHz	(within −3dB)
AC	5 mV position	3Hz to 150 MHz	(within −3dB)
	10 mV positions	3Hz to 200 MHz	(within −3dB)

Rise Time

5mV position	Approximately 3.5 nsec (nsec=nanosecond=10^{-9} second)
10 mV positions	Approximately 1.75 nsec

Frequency Bandwidth

50 MHz range	DC – 50 MHz (rise time 7 nsec)	−3 dB
FULL range	DC – 200 MHz	−3 dB

Square Wave Characteristics

The square wave characteristics corresponding to the position of the VOLTS/CM switch are presented in Table 1−1. The values shown are for an input square wave with a rise time of less than 1 nsec.

Table 1−1

VOLTS/CM switch in 5 mV and 10 mV positions	
Overshoot	5 % or less
Undershoot	3 % or less
Ringing	5 % or less
Sag (at 1 MHz)	1 % or less
Sag (at 60 Hz)	1 % or less

Signal Delay Time

Approximately 80 nsec

Input Signal Coupling Mode

Three (3) coupling modes, AC, DC and GND (to identify the ground potential on display) are available.

In the DC position, the input signal is coupled directly to the vertical amplifier and in the AC position, it is coupled through a blocking capacitor. Attenuation for low AC frequency in the AC position is −3 dB at approximately 3 Hz.

Input Impedance

Direct	1 megohm shunted by approx. 14pF
With probe (10: 1)	10 megohms shunted by approx. 10pF

Maximum Input Voltage

500 V (DC + AC peak)

Mode Selection

CH 1	CH 1 only
CH 2	CH 2 only
ALT	Alternate sweep of CH 1 and CH 2
CHOP	Chopped switching (at approx. 1 MHz) of CH 1 and CH 2
ADDED	CH 1 ± CH 2

Polarity Inversion

The polarity of the CH 2 display can be switched to NORMAL or INV (inverted).

Common Mode Rejection Ratio

In the ADDED (CH 1−CH 2) mode, CH 1 and CH 2 form a differential input circuit. The common mode rejection ratio (CMRR) in this mode is more than 20:1 (for an input signal of 10 MHz).

Linearity

When a signal displayed at the center of the CRT with a vertical amplitude of 20 mm is moved to the top or bottom of the horizontal graticule scale, the variation in the vertical amplitude of the display is within ±3 % (±0.6 mm).

Drift

After 15 minutes warmup time, drift, or vertical shift of a display is:

5 mV position	5 mm/hour
Other positions	3 mm/hour

CH 2 OUT Signal

The signal fed to the CH 2 input is amplified by five (5x), and is available at the CH 2 OUT terminal.

The performance shown in Table 1–2 is obtained when the CH 2 OUT is connected to the CH 1 input (cascade connection of CH 1 and CH 2), and both VOLTS/CM switches are in the 5 mV/cm positions with the VARIABLE knobs in the CALIB position.

Table 1–2

Item	Performance and Accuracy
Sensitivity	1mV ±3%
Bandwidth	DC~30MHz, within −3dB
Noise	5mmp-p or less

Internal Trigger Selection

To insure stable triggering in internally triggered dual-trace measurement, the trigger signal can be selected from either CH 1 or CH 2.

▶Horizontal Deflection System

The horizontal deflection system provides three functions:

Main Sweep	(A Sweep)
Delayed Sweep	(B Sweep)
External Sweep	(XY Scope)

A Sweep Time (A TIME/CM)

Twenty-seven (27) calibrated sweep times from 10 nsec/cm to 5 sec/cm are available. Continuous variation of the sweep time is also possible by using the A VARIABLE knob which reduces the rated sweep time by 2.5 times (or more). The lowest sweep time is 12.5 see/cm (or more).

The accuracy of each sweep time with A VARIABLE knob in the CALIB position is within ±3 % of the rated value.

B Sweep Time (B TIME/CM)

Twenty-three (23) calibrated sweep times are available and the B TIME/CM VARIABLE knob performs a function similar to the A VARIABLE.

The accuracy of each TIME/CM position with the B TIME/CM VARIABLE knob in the CALIB position is within ±3 % of the rated value.

Sweep Linearity

The linearity of both the A and B sweeps at any position of the TIME/CM switch is within ±3 % of the rated value. (provided, however, that the display is positioned within 4 cm of the center of the CRT).

Sweep Magnifier

The display can be horizontally magnified by 10 times.

Maximum Sweep Time

Approximately 1 nsec/cm

Delay Time

A continuously variable sweep delay from 1 μsec to 50 sec is available and, by using the A VARIABLE knob, the delay can be extended up to approximately 125 sec. When a calibrated delay time is not required, a delay time between 20 nsec and 0.5 μsec is available.

Delay Jitter

When the display is expanded by the delayed sweep, jitter is caused on the display. The amount of jitter is determined by the ratio of A and B TIME/CM range, however, jitter of approximately 10 mm in width on the graticule will occur with an A TIME/CM to B TIME/CM in ratio of 20000:1.

Single Sweep

Two single sweep modes, normal and delayed, are available.

External Sweep

In order to sweep the horizontal axis with an external signal, the external signal may be fed either to the TRIG OR HORIZ IN connector, or to the CH 2 INPUT connector.

Performances for both of these are shown in Tables 1–3 and 1–4, respectively.

Table 1–3

Item	Performance and Accuracy
Input Impedance	1megohm shunted by 20pF
Deflection Sensitivity	Within 0.1V/cm ±10% at SOURCE switch in EXT position
	Within 1V/cm ± 20% at SOURCE switch in EXT ÷ 10 position
Bandwidth	DC~ 3 MHz within −3dB
Bandwidth Applicable to Phase measurement	DC~100kHz (phase difference at 100kHz: 3° or less)

Table 1–4

Item	Performance and Accuracy
Input Impedance	1megohm shunted by 14pF
Deflection Sensitivity	Within ±3% of CH2 VOLTS/CM switch position
Bandwidth	DC~1MHz within −3dB
Bandwidth Applicable to Phase Measurement	DC~100kHz (phase difference at 100kHz: 3° or less)

▷ Triggering

Individual triggering is provided for each sweep; the A triggering for the A sweep and B triggering for the B sweep.

–A Triggering–

Trigger Source

Any one of four triggering sources, INT, EXT, EXT ÷ 10, or LINE can be selected.

Polarity

+ (Sweep is triggered by the positive going slope of input signal), and – (Sweep is triggered by the negative going slope of input signal).

Trigger Coupling

Four types of trigger coupling modes are available: AC, LF REJ, HF REJ, or DC. The triggering frequency range of each mode is shown in Table 1–5.

Input Impedance of TRIG INPUT connector

1 megohm shunted by 25 pF or less.

Triggerable Frequency Range and Trigger Level

The triggerable frequency range and level are shown in Table 1–5.

Auto and Normal Trigger Mode

The A SWEEP MODE switch is used to select the Auto or Normal triggering mode of the A SWEEP. In the Auto mode, the sweep circuit will not be triggered by signals below 50 Hz even if the COUPLING switch is set in the DC position. When a trigger signal is not present, the sweep will free run. In the Normal trigger mode, the sweep can be triggered from DC. When a trigger signal is not present, only a spot will appear on the CRT.

Table 1–5 Triggerable Frequency Range and Level of A Triggering

A SWEEP MODE	COUPLING	Triggerable Frequency Range	Trigger Level	
			Internal Trigger (display amplitude)	External Trigger (Voltage)
NORM and AUTO	AC	30 Hz~ 15MHz	2mm or more	25mV or more
		50MHz	10mm or more	100mV or more
		100MHz	30mm or more	150mV or more
	LF REJ	30 kHz~ 15MHz	2mm or more	100mV or more
		50MHz	10mm or more	25mV or more
		100MHz	30mm or more	150mV or more
	HF REJ	30 Hz~ 50 kHz	2mm or more	25mV or more
	DC	DC ~ 15MHz	2mm or more	25mV or more
		50MHz	10mm or more	100mV or more
		100MHz	30mm or more	150mV or more
HF	AC LF REJ DC	10MHz~100MHz	5mm or more	25mV or more
		150MHz	30mm or more	40mV or more
		200MHz	————	70mV or more

Caution: In the AUTO triggering mode, the sweep is not triggered by signals lower than 50Hz, even if the COUPLING switch is the DC position.

–B Triggering–

Trigger Source

Any one of four triggering sources, INT, EXT, EXT ÷ 10, or LINE can be selected.

Polarity

+ (sweep is triggered by the positive going slope of input signal), and – (sweep is triggered by the negative going slope of input signal).

Trigger Coupling

Four types of trigger coupling modes are available: AC, LF REJ, HF REJ, or DC. The triggering frequency range of each mode is shown in Table 1–6.

Input Impedance of TRIG OR HORIZ INPUT connector

1 megohm shunted by 25 pF or less.

Triggerable Frequency Range and Trigger Level

The triggerable frequency range and level are shown in Table 1-6.

Table 1–6 Triggerable Frequency Range and Level of B Triggering

DLY'D(B) MODE	COUPLING	Triggerable Frequency Range	Trigger Level	
			Internal Trigger (display amplitude)	External Trigger (Voltage)
TRIG'D	AC	30 Hz~ 15MHz	10mm or more	100mV or more
		50MHz	20mm or more	200mV or more
	LF REJ	30kHz~ 15MHz	10mm or more	100mV or mor
		50MHz	20mm or more	200mV or more
	HF REJ	30 Hz~ 50 kHz	10mm or more	100mV or more
	DC	DC ~ 15MHz	10mm or more	100mV or more
		50MHz	20mm or more	200mV or more

▶Signal Outputs

A GATE

Positive square wave synchronized with A SWEEP and approximately .5 V p-p amplitude with a load of 100 kilohms or more.

Out put resistance 1.5 kilohms

B GATE

Positive square wave synchronized with B SWEEP and approximately 5 V p-p amplitude with a load of 100 kilohms or more.

Output resistance 1.5 kilohms

▶Calibrator

The calibration voltage is obtained from the CAL OUT connector. Characteristics of this output are shown in Table 1–7.

Table 1–7

Item	Characteristics and Accuracy
Voltage	Square wave 5mVp-p to 10Vp-p in 11steps, within ±2%
Frequency	1kHz ±1%, or less
Duty Ratio	49 : 51, or less
Rise and Fall Time	Rise time 0.1μsec or less Fall time 0.5μsec or less

Calibration Current

The square wave current described in Table 1–8, flows through the current calibrator loop in the direction indicated by the arrow.

Table 1–8 Calibration Current Characteristics

Item	Characteristics and Accuracy
Current	Square wave 5mAp-p, within ±2%
Frequency	1kHz, within ±1%

▶Cathode Ray Tube Circuit

Cathode Ray tube (CRT)

Type: D13-45, 5-inch rectangular type, parallax free, internally marked graticule.

Effective Display Area: 60 mm (vertical) x 100 mm (horizontal)

Acceleration Voltage

Approximately 15 kV

External Intensity Modulation

Minimum intensity modulation voltage: +4 ~ +15 V

Input impedance: 20 kΩ shunted by 30pF

▶Power Requirements

Voltage Range

By selecting an appropriate position of the LINE VOLTAGE RANGE switch located inside the rear panel, this instrument can be used with the line voltages (commercial power sources) shown in Table 1–9. (This model is normally supplied for use on 100 V sources, however, it can be easily modified for 200 V use when requested.)

Table 1–9 Operating Voltage

Type	LINE VOLTAGE RANGE	Applicable Line Voltage Range
100V use	LOW	90~110V
	HIGH	105~126V
200V use	LOW	180~220V
	HIGH	207~253V

Line Frequency

50/60 Hz

Power Consumption

Approximately 160 W (at 100 V line voltage)

▶Environmental Conditions

Temperature Range

The environmental temperature range for normal operation of this instrument is from −10° C to +50° C.

Humidity Range (Relative Humidity)

This instrument operates normally with a relative humidity of up to 90 % at 50° C.

Vibration

This instrument will operate normally after a vibration test wherein the instrument is subjected to vibractions with an amplitude of 1.5 mm at 1000 cycles per minute along each of the three major axes for one hour.

Shock

Operation of this instrument is normal after three shock tests for each major axis. This can be performed by raising one edge of the equipment 5 cm above a rigid test bed (or an incline of 30 degrees, whichever is smaller) and releasing it.

▶Construction

Dimensions

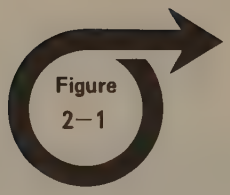
Approximately 215 mm W x 305 mm H x 495 mm L

Weight

Approximately 16 kg

Color

Front Panel	White aluminum
Cabinet	Vinyl coated



Figure
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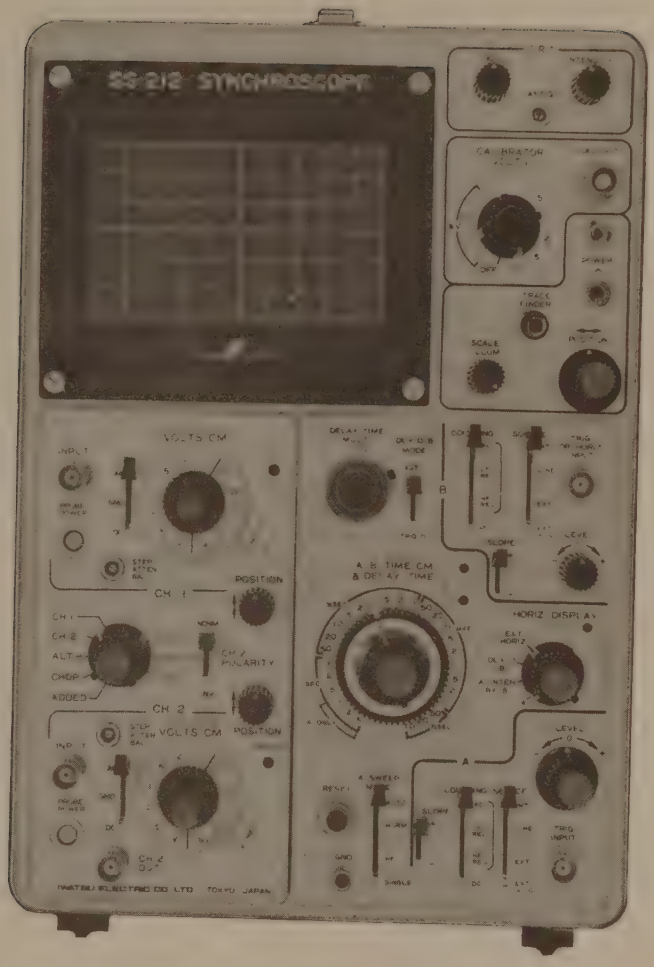
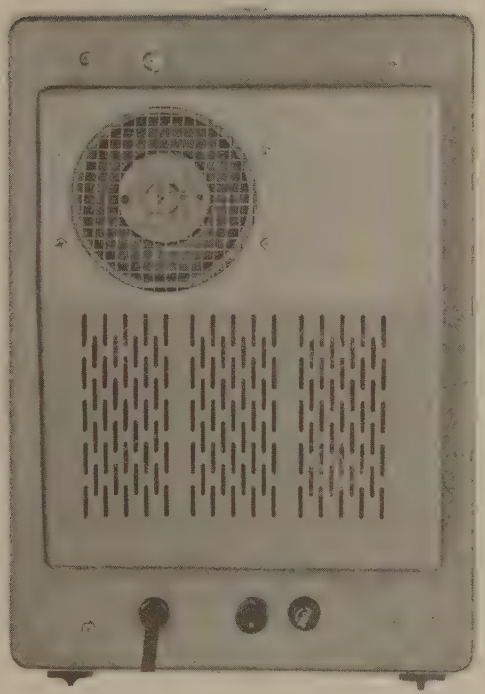
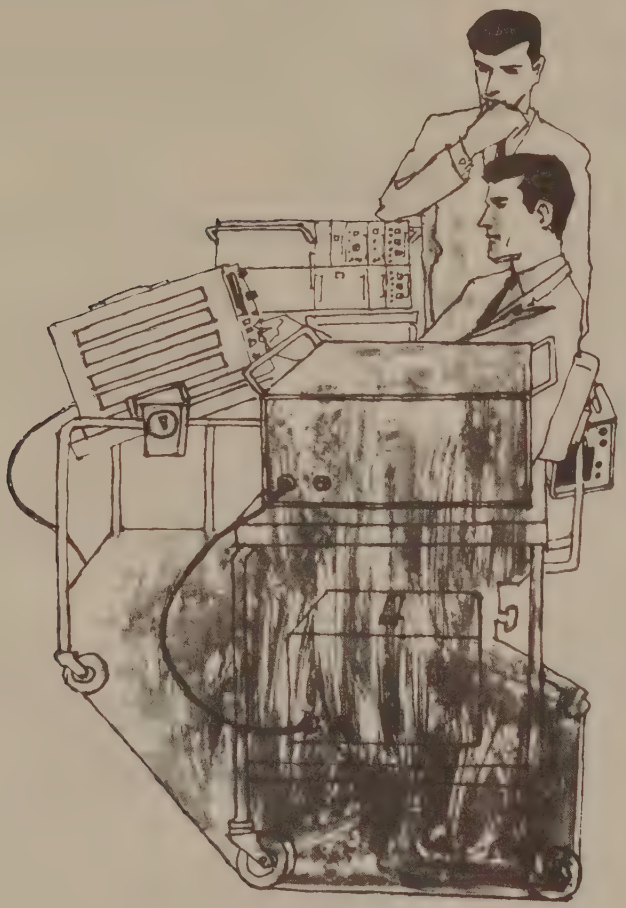

SS-212 SYNCHROSCOPE
CALIBRATOR
POWER
TRACE FINDER
SCALE ILLUM
FOCUS
VOLTS/CM
INPUT
POSITION
CH 1
CH 2
ALT
CHOP
ADDED
A, B TIME/CM & DELAY TIME
HORIZ DISPLAY
EXT HORIZ
LEVEL
SLOPE
TRIG INPUT
A SWEEP MODE
REPET
SLOPE
AUTO
NORM
SINGLE
TRIG
TOKYO JAPAN

A GATE
TRACE ROTATION
B GATE
CAL.0
SWEEP



CHAPTER 2. OPERATION



For effective use of this instrument, the operator must be familiar with the functions and operation.

In this chapter, handling precautions and the functions of panel controls are described beginning on Page 2–14.

Handling Precautions 2– 2
Description of Panel Controls 2– 2
Operating Procedure 2– 7
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Applying Signal and Trigger 2– 7
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▷ Handling Precautions

Panel Cover

A panel cover is provided to protect the front panel and is removed by unlocking the two spring fasteners. Be sure to install the cover over the front panel before transporting the instrument.

For convernient observation, the auxiliary stand on the bottom front of the instrument may be used to provide an optimum tilt angle.

Polarized Filter

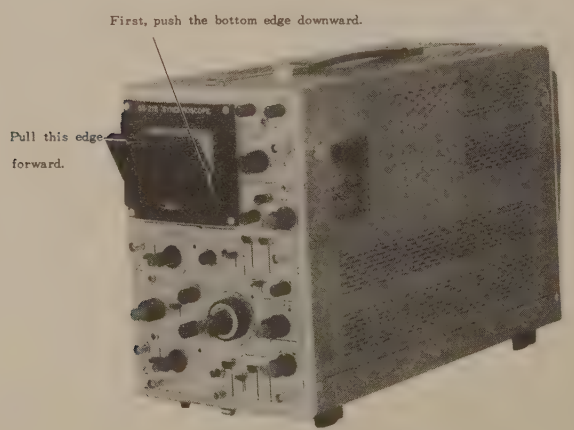
A mesh-filter is employed in this instrument, with a polarized filter also furnished as a standard accessory to absorb external light and prevent it from reflecting from the C.R.T. surface. These filters also increase the contrast of the trace for proper observation. Use these filters referring to the features shown in Table 2–1.

When photographing a display, the mesh-filter should be removed to increase definition. The mesh-filter can be easily removed by pushing its bottom edge downward and pulling the tope edge forward as shown in Figure 2–2. This filter is subject to damage and should therefore be handled carefully when removing or inserting.

Table 2–1

Polarized filter	Mesh filter
The reflecting of incident light from the C.R.T. surface through polarized-filter can be observed, but a surface reflection on this filter causes difficulty in observation. FOCUS: Good	No reflection of incident light both from C.R.T. and the mesh filter surfaces. FOCUS becomes worse because of diffraction.

Figure 2–2 Removal of Filter



▶Description of Panel Controls

The function of switches, controls, and connectors on the front, right, and rear panels are described in this section. For concentric knobs, the black markings on the panel indicate the black knob position, and the red markings indicate the position of the red knob. Refer to Figure 2–1.

▷ Front Panel

–Power Supply and CRT Circuit–

POWER ON

Line switch. When turned to the ON position, power is supplied to the internal circuits and the pilot lamp lights.

SCALE ILLUM

Controls illumination of graticule. Lamps are intensified by clockwise rotation of this control, and go off at extreme counterclockwise position.

TRACE FINDER

A push-button switch to locate the trace or spot position. When no trace or spot is visible in the viewing area, the position of the beam is indicated by pressing this button. For example, if the trace is beyond the top of the viewing area, the trace will appear at the top of the graticule when this button is depressed.

While holding this button in, move the trace to the center of the graticule with the POSITION (VERT.) control. Release the button and the trace will remain at the center of the viewing area.

A trace positioned to the left or right of the viewing area can be located in the same manner. In this case, use the horizontal POSITION control to return the trace to the center.

INTENSITY

Controls brightness of trace or spot. The trace is intensified by clockwise rotation of this control, and dimmed by counterclockwise rotation.

FOCUS

A control to focus the trace or spot on the CRT.

ASTIG

A screwdriver adjusted control used to improve focusing. When sharp focusing is not obtained by adjusting the FOCUS control, adjust the ASTIG control in conjunction with the FOCUS.

–Vertical Deflection System–

Corresponding controls and connectors for CH 1 and CH 2 function identically, therefore these will be described collectively.

MODE (Black Knob)

Determines operating mode of dual trace vertical axis amplifier. The following modes are available.

CH 1
Selects CH 1 amplifier only. In this position, the instrument operates as a single trace synchroscope.

CH 2
Selects CH 2 amplifier only. The instrument also operates as the single trace synchroscope.

ALT
Operation of CH 1 and CH 2 is alternately switched after each horizontal sweep.
Signals connected to these inputs are displayed alternately. Simultaneous display of each signal becomes impossible at slow sweep speeds (below approximately 2 msec/cm). The ALT mode is suitable for comparatively high frequency input signals. Simultaneous single sweep measurement of two signals is impossible in the ALT mode.

CHOP
Signals from CH 1 and CH 2 amplifiers are switched at a repetition rate of approximately 1 MHz, and are simultaneously displayed.
In this mode, the signals are displayed as dotted lines. and signals may become inconvenient to observe at high sweep speeds of approximately 5 μsec/cm or above. The CHOP mode operation is preferred for measureing comparatively low frequency signals.

ADDED
CH 1 and CH 2 amplifiers simultaneously operate, and the algebraic sum or difference of these signals is displayed.

TRIGGER (Red knob)

Selects the source of the internal trigger in the ALT, CHOP and ADDED positions of the MODE switch. In other words, when the MODE switch is in one of these positions and the TRIGGER switch is set to the CH 1 position, the sweep circuit is triggered by the CH 1 input signal. When the trigger switch is in the CH 2 position, the sweep is triggered by the CH 2 input signal.
When the MODE switch is set to the CH 1 or CH 2 position, the TRIGGER switch is separated from the circuit, and the sweep is triggered by the input signal indicated by the MODE switch. That is, when the MODE switch is set to the CH 1 position, the horizontal sweep is triggered by the CH 1 input signal regardless of the TRIGGER switch position.

CH 2 POLARITY

A switch to select output polarity of CH2. In the NORMAL position, a normal output (in-phase with input) is obtained, and in the INV position, the polarity is reversed.

INPUT

A BNC type connector to connect the signal to be measured. When a probe is used for measurements, its output is connected to this connector.

PROBE POWER

When the optional source follower probe is used for measurement, power for the probe is supplied from this connector.

AC-GND-DC

A switch to select the input coupling mode.
In the AC position, the input signal is coupled to the vertical axis amplifier through a coupling capacitor. The DC component of the input signal is blocked and only the AC component is displayed.
In the DC position, the input signal is directly coupled to allow the display of all components, including the DC component of the input signal.
In the GND position, the input of the vertical axis amplifier is disconnected from the INPUT connector and grounded to aid in determining the ground potential of the display (This is normally used as a reference level for measurement).

VOLTS/CM (Black knob)

A switch to select a vertical deflection sensitivity from 5 mV/cm to 5 V/cm in 10 steps. An appropriate position must be chosen for adequate display size.
When the VARIABLE control is turned fully clockwise (CABLE), the voltage per one division (1 cm) of the graticule is that indicated by the position of the VOLTS/CM switch.

VARIABLE (Red knob)

A continuously variable control to attenuate the input signal. The maximum attenuation ratio of 1/2.5 (or more) is obtained at the fully counterclockwise position of this control. Therefore, continuous attenuation between steps of the VOLTS/CM switch is possible.
For quantitative measurement of input signal, the VARIABLE should be set to the CALIB position.

STEP ATTEN BAL

If the vertical axis input circuit is not well balanced, the vertical position of the trace (or spot) shifts when the 5 mV or 10 mV position of the VOLTS/CM switch is changed. This screwdriver adjust control is used to eliminate the vertical shift of the trace.

POSITION

A control to adjust the vertical position of the trace or spot. When this control is turned clockwise, the trace moves upward; it moves down with counterclockwise rotation.

CH 2 OUT

The input signal connected CH 2 is amplified 10 times, and is available at this connector. Output impedance is 50 ohms.

–Horizontal Deflection System–

HORIZ DISPLAY (Black knob)

Selects one of the following four horizontal deflection modes.

A

A mode used for ordinary waveform measurement. Horizontal sweep is produced by a sawtooth wave generated in the A SWEEP GENERATOR. Sweep time is determined by the A TIME/CM switch and A VARIABLE control.

Triggering of this sweep mode is controlled by the controls located on the lower right section of the front panel (enclosed in thick line "A").

A INTEN BY B

For use of delayed sweep observation (an optional portion of the input signal is expanded in the delayed sweep; this function is described in the following paragraph, DLY'D (B)), the portion of the A sweep which is swept by the B sweep is intensified more than the normal A sweep. (Refer to "Operating procedure, Delayed Sweep Operation" for details of this function.)

DLY'D (B)

In this mode, the sweep is delayed, and the intensified part of the display obtained above (A INTEN BY B) is magnified in the horizontal display area.

(Refer to "Operating Procedure Delayed Sweep Operation" for details of this function.)

EXT HORIZ

This is the external sweep (X-Y scope) mode. Operation of the internal sweep generator is inactivated in this mode, and the horizontal axis is swept by an external signal fed to the "TRIG OR HORIZ INPUT" or "CH 2 INPUT" connector.

MAG (Red knob)

This switch is used to magnify the horizontal display by 10 times. At the X10 position, the horizontal display is magnified, and the sweep time becomes 10 times faster than the indication of the A, B TIME/CM switch.

Magnification Indicator Light

When lit, this indicates that the sweep is magnified by 10 times.

A SWEEP MODE

This switch determines the operation mode of the A SWEEP circuit.

AUTO

The A SWEEP circuit is triggered in the AUTO trigger mode. In this mode, the triggering mode automatically changes to free running; when the input trigger frequency drops below 50 Hz; when a trigger signal is not present; or when the LEVEL control is set to a point which exceeds the trigger point (i.e., the point on input signal waveform from which the trigger pulse in initiated).

The triggering frequency range in this mode is from 50Hz to 150 MHz.

NORM

The A SWEEP circuit is triggered in the Normal trigger mode. In this mode, the sweep stops and only a spot is present when a trigger signal is not applied, and when the LEVEL control exceeds the trigger point. The triggerable frequency range in this mode is from DC to 150 MHz.

HF

In this position an input signal having high frequencies can be triggered. The triggerable frequency ranges from 10 MHz to 200 MHz. However, for the internal trigger source the upper limit is 150 MHz, and therefore frequencies higher than this limit must be triggered by an external trigger source.

SINGLE

This control provides single sweep operation. The horizontal deflection circuit is swept only once. Single sweep operation is possible only at the A, A INTEN BY B or DLY'D (B) positions of the HORIZ DISPLAY switch.

RESET

This pushbutton switch contains a lamp, which functions as a switch and an indicator.

The switch portion is used to initiate the single sweep, and the reset the circuit for another sweep when a trigger signal is applied.

As an indicator, the button lights during the time the circuit is reset and awaiting the next trigger.

A, B, TIME/CM AND DELAY TIME (White and black knobs)

The larger white knob indicates the A TIME/CM range and DELAY TIME, and the smaller black knob indicates the B TIME/CM range.

The A TIME/CM (DELAY TIME) control is used to select a sweep time from 20 nsec/cm to 5 sec/cm in 27 steps. The optimum position for an observation should be determined in accordance with the frequency and rise time (or fall time) of the input signal.

This switch also determines the delay time in delayed sweep operation.

When the A VARIABLE control is turned fully clockwise (CALIB position—UNCALIB light goes off), the sweep time can be read directly from the indication of the TIME/CM switch. The delay time can also be read directly by setting the A VARIABLE control to the extreme clockwise position and by multiplying the A TIME/CM

indication and the DELAY TIME MULTI indication. It should be noted however, that the DELAY TIME MULTI indication becomes uncalibrated in the A TIME/CM switch ranges from 10 nsec to 0.5 μsec. In these switch position, the UNCALIB indicator lights to indicate that the sweep is not calibrated.

The B TIME/CM switch selects a sweep time from 10 nsec/cm to 1 sec/cm in 24 steps for the delayed sweep mode.

The sweep time in the delayed sweep mode can also be read directly from the panel indication by turning the B TIME/CM VARIABLE control fully clockwise (CALIB position – the UNCALIB indicator goes off).

A VARIABLE (Red knob)

Provides continuous variation of A sweep time. By adjusting this control, the sweep time indicated by the A TIME/CM switch can be extended by 2.5 times (or more).

The sweep speed becomes slower with counterclockwise rotation of this control. For quantitative measurements, this control should be set to the CALIB position.

UNCALIB

The Indicator lights to indicate that the sweep time or delay time is not calibrated.

The light lights in the following two cases to indicate that the A sweep or B sweep time is uncalibrated.

(1)When the HORIZONTAL DISPLAY switch is set to the A, or A INTEN BY B position, and the A VARIABLE control is in a position other than CALIB.

(2)When the HORIZ DISPLAY switch is set to the DLY'D (B) position, and the B TIME/CM VARIABLE control is in a position other than CALIB.

The indicator lights in the following two cases to indicate that the delay time is not calibrated.

(1)When the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position, and the A TIME/CM switch is positioned in the range between 20 nsec and 0.5 μsec.

(2)When the HORIZ DISPLAY switch is set to the A INTEN BY B or DLY'D (B) position, and the A VARIABLE control is in a position other than CALIB.

DLY'D (B) MODE

This switch selects the delay sweep mode; triggered or non-triggered, and is effective only when the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position.

In the AUTO position, the delayed sweep becomes a non-triggered mode, and in the TRIG'D position the delayed sweep is triggered.

DELAY TIME MULTI

This control continuously varies the delay time, and the desired portion of the input signal can be expanded in the display area.

POSITION (Black knob)

This control adjusts the horizontal position of the trace or spot. Clockwise rotation of this control moves the trace to the right, and counterclockwise rotation shifts the trace to the left.

FINE (Red knob)

This control is used for fine adjustment of horizontal positioning.

This control is particularly effective for positioning of the magnified horizontal display (magnified by 10 times by using the MAG switch).

GROUND

A ground terminal.

–Trigger Circuit–

Switches and connectors in the trigger circuit are classified into those related to the A sweep (grouped and enclosed in the thick line marked A-lower right section of front panel) and those for the B sweep (enclosed in thick line marked B, right center section of front panel), however, the function of the corresponding controls in the two circuits is practically identical.

The follwoing descriptions, therefore, are for the controls and connectors of the A sweep unless otherwise stated.

SOURCE

This selects one of the following trigger signal sources.

The SOURCE switch in B sweep circuit is also used to select the signal source for external sweep. (Refer to "Operating Procedure, Proper Triggering" for details).

INT

Sweep is internally triggered by the input signal fed to the INPUT connector.

LINE

Sweep is triggered by line frequency. The line frequency signal is fed to the trigger circuit.

EXT

Sweep is externally triggered. The input signal, or a signal of which the timing is a multiple of the input signal, must be connected to the TRIG INPUT connector (TRIG OR HORIZ INPUT for B sweep). This connector is also used to connect an external sweep.

EXT ÷ 10

The external trigger signal is attenuated by 10:1 in this positon. This is advantageous when the external trigger signal is excessively large and the proper triggering point cannot be obtained in the EXT mode.

This position can also be used to attenuate the external sweep input signal by 10:1,

TRIG INPUT

This is used for connecting an external trigger signal.

The TRIG OR HORIZ INPUT for the B sweep is also

used for connecting an external sweep input in the external sweep mode.

The input impedance of this connector is 1 M ohm (shunted by 25 pF or less), and the maximum input voltage is 100 V p-p. Avoid connecting an excessively high voltage signal source.

COUPLING

In order to ensure stable triggering, the external trigger must be properly coupled to the trigger circuit. (Refer to "Operating Procedure, Proper Triggering" for details)

The COUPLING switch in the B sweep circuit is also used to select the coupling mode for an external sweep.

In the external sweep mode, the LF REJ, and HF REJ positions should not be used normally.

AC

The trigger signal is AC coupled. Since the DC component of the trigger signal is blocked, influence of the DC voltage on the trigger signal is eliminated.

LF REJ

The external trigger signal is connected to the trigger circuit through a high-pass filter, and low frequency noise superimposed on the trigger signal, or low frequency components (below approximately 30 kHz) in the signal, are blocked.

HF REJ

The external trigger signal is connected to the trigger circuit through a low-pass filter. High frequency noises, or high frequency trigger signals (above approximately 50 kHz) are blocked.

DC

The external trigger signal is coupled directly to the trigger circuit and the sweep can be triggered by a very low frequency, or DC.

SLOPE

This control selects slope of the trigger signal which starts the sweep. The sweep can be triggered from negative

(–) or positive (+) going portion of input signal.

LEVEL (Black knob)

This selects that amplitude of trigger signal at which sweep is triggered.

HF STABILITY (Red knob)

When the sweep is triggered by a signal higher than approximately 10 MHz, jitter may be presented even at the optimum adjustment of the LEVEL control. This control is used to eliminate this jitter.

–Calibrator–

CALIBRATOR VOLTS

The switch selects the amplitude of the calibration voltage available at the CAL OUT connector.

Calibration voltages from 5 mV to 10 V in 11 steps are provided. The calibration oscillator stops when this switch is turned to the OFF position.

CAL OUT

This a connector is used to supply the calibration output voltage (frequency approximately 1 kHz) selected by the CALIBRATOR VOLTS.

Output impedance is 50 ohms in the red marked range of the CALIBRATOR VOLTS switch, and becomes higher in the ranges above .5 V.

▷ Left Side Panel

BAND WIDTH

This switch eliminates noise components by changing frequency bandwidth of the vertical deflection system for clear trace display. The frequency bandwidth is held at 200 MHz in the FULL range, while that of CH 1 and CH 2 is reduced to 50 MHz in the 50 MHz range.

▷ Right Side Panel

B TIME/CM VARIABLE

This is a fine adjustment for B sweep time.

The control extends the indicated sweep time of B TIME/CM, by 2.5 times (or more). With counterclockwise rotation of this control, the sweep speed is reduced. For quantitative measurement, this control should be set to the CALIB position.

A GATE

A square-wave output of approximately 5 V p-p coincident with the A sweep is obtained at this connector. Output resistance is approximately 1.5 kilohms.

TRACE ROTATION

A screwdriver adjustment ia available hove to align the trace with the horizontal graticule lines. This adjustment is provided to compensate for variations in the earth magnetism.

B GATE

A square wave output of approximately 5 Vp-p coincident with the B sweep is obtained at this connector. Output impedance is approximately 1.5 kilohms.

PROBE LOOP

When the CALIBRATOR VOLTS switch is set at any position other than OFF, a 1 kHz square-wave current of 5 mA flows in the direction indicated by the arrow. This current is used for calibrating the current probe. The current waveform is picked up by clipping the probe over the loop.

▷ Rear Panel

POWER INPUT

This connector is used to connect the power cable.

LINE VOLTAGE RANGE

This switch selects the applicable power source voltage.

In the LOW position, the instrument operates on a source voltage of 100 V ±10 %, and in the HIGH position, operates on 115 V ±10 %.

By a simple change of transformer connections, the instrument can be operated on 200 V ±10 % (LOW position) or 230 V±10 % (HIGH position).

2A SLOW

This fuse holder contains a 2 Amp. slow-blow fuse. The fuse will blow in the event excessive current is drawn during operation but will not blow as a result of surge current when the POWER switch is turned ON.

Z AXIS INPUT

This connector is used for external intensity modulation. Input impedance is approximately 20 kilohms, and the maximum allowable voltage is 200 V p-p.

▶Operating Procedure

The best way to become familiar with the operation of this instrument is to apply various input signals and operate the controls. The internal circuits will not be damaged by mis-handling of the panel controls and switches. However, the precautions described in the following section "Pre-start operation" should be observed.

▷ Pre-Start Operation

Do not Apply Excessive Input Signals

The maximum allowable input voltages which can be applied to the CH 1 or CH 2 INPUT, and the probe tip are 500 V(DC + AC peak). Avoid connecting any voltage in excess of these ratings.

(IWATSU voltage dividers and high voltage probes are available for high voltage measurements).

Check source voltage

Check the voltage of the power source. This instruments is designed to be used on the line voltages shown in Table 1–9. Set the LINE VOLTAGE RANGE switch to a position which coincides with the available line voltage. Operating this instrument on line voltages other than those listed in the table may cause trouble. If a suitable source voltage is not available an adequate transformer or regulator is required.

(IWATSU can provide automatic voltage regulators for use in areas where the line voltage fluctuates excessively. Refer to the section on "Associated Equipment and Accessories." for more information).

Ambient temperature

The ambient temperature range for normal operation of this instrument is from −10°C to +50° C. Avoid using this instrument in conditions exceeding this range.

Do not leave an intensified spot stationary for long periods

Excessive intensity of a spot or trace, especially when left in one place for a long period, may damage the phosphor on the CRT, or other related parts.

Do not use excessive force on the switches or controls

Faulty manipulation of switches and/or controls will not damage the internal circuits, but rough handling of these controls may mechanically damage them.

▷ Applying Power and Obtaining a Sweep

Now you are ready to proceed with actual operation.

Turn the POWER on, and intensify spot

Turn the POWER switch OFF and connect the power cable to the POWER INPUT connector. Plug the other end into an appropriate line voltage outlet, and place the following controls in the positions indicated below.

INTENSITY	Fully clockwise
MODE	CH 1
CH 2 POLARITY	NORM
AC-GND-DC	GND
POSITION	Mid range
HORIZ DISPLAY	A
MAG	XI
A SWEEP MODE	NORM
POSITION	Mid range

Turn the POWER switch ON. The instrument is operational in 15 seconds after it is turned on.

Turn the POSITION control clockwise until the spot appears in the viewing area. The spot should be excessively bright. Turn the INTENSITY control counterclockwise until the desired intensity is obtained.

Focus the Spot

Adjust the vertical POSITION and horizontal POSITION alternately to move the spot to the center of the viewing area. Adjust the FOCUS control for a sharp, well defined spot. (When an input signal is applied and displayed, the edges of the display may be slightly out of focus. Adjust the ASTIG and FOCUS controls for a sharp display throughout the entire viewing area).

Sweep

When the A SWEEP MODE switch is changed to the AUTO position, the sweep should start. The sweep may become somewhat unstable at the mid-position of the LEVEL control. This is not a defect and the sweep will be stabilized by turning the control slightly to the right or left.

The INTENSITY control may have to be readjusted for adequate trace intensity. With the controls set as instructed above, the trace starts from the center of the CRT and sweeps to the right. Turn the horizontal POSITION control counterclockwise to move the sweep start to the left edge of the graticule.

Turn the A TIME/CM switch and the A VARIABLE control and confirm that the sweep time varies in accordance with the controls.

▷ Applying Signal and Trigger

Connect Input Signal

The next step is a practice operation to display a waveform, using the CALIBRATOR VOLTS output as an input signal.

Connect the CAL OUT connector to the CH 1 INPUT connector by using the accessory jumper cable, and place the following controls in the positions indicated.

VOLTS/CM (CH 1) .2

VARIABLE (CH1)	CALIB position
CALIBRATOR VOLTS	.5

Change the AC-GND-DC switch to the DC position, and set the A TIME/CM switch to the 2 msec position. The calibration voltage should be displayed as a square wave approximately 2.5 cm in amplitude.

Turn the VOLTS/CM counterclockwise through its steps. The vertical amplitude should decrease in accordance with the steps. Confirm that the amplitude continuously decreases with counterclockwise rotation of the VARIABLE control. Return the VARIABLE control to the CALIB position, set the VOLTS/CM switch to the 2 V/CM position, and set the CALIBRATOR VOLTS to the 5 V position. The display amplitude should return to 2.5 cm. Through these operations, the relationship between the input signal, VOLTS/CM switch and the VARIABLE control should be clear.

Since the above signals are displayed in the free-run mode, the horizontal display is not stable and may be difficult to observe. When the A TIME/CM switch is set at a high sweep speed to magnify a part of the display, the display will become a number of horizontal lines.

When the sweep is properly triggered, the display will be stable and if required, a portion of the displayed waveform can be magnified.

Before Triggering

Proper triggering is a key point in operating a synchroscope. In general, the following items must be predetermined prior to triggering the sweep.

(1) Selection of trigger mode
Internal trigger (INT), external trigger (EXT or EXT ÷ 10), or line trigger (LINE).

(2) Selection of trigger signal coupling mode
AC, LF REJ, HF REJ, or DC coupling.

(3) Selection of trigger polarity
Trigger on positive (+) or negative (—) going slope of input signal. (Refer to the item on "Proper Triggering" for details.

In this practice operation, the sweep will be triggered in the AC coupled, internal trigger (INT) mode and triggered by the positive going slope of the input signal. Therefore, the trigger controls must be set as follows.

SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+

PROPER TRIGGERING

SOURCE Switch

For stable display of input signal waveforms, the sweep circuit must be triggered by the input signal, or a signal which is a certain (an integral multiple) relation to the input signal with regard to time, — this signal is called the trigger signal. The trigger signal is fed to the trigger generator wherein the trigger pulse is generated, and the trigger pulse then triggers the sweep circuit.

The triggering method wherein the SOURCE switch is set to the INT position and a portion of the input signal to be measured is internally (from the vertical deflection system) fed to the trigger generator, is called the internal trigger method (refer to Figure 2–3). The external trigger method requires the connection of an external signal, having a direct or a certain time relationship to the input signal as the triggering signal for the trigger generator. In this mode, the SOURCE switch must be set to the EXT or EXT ÷ 10 position. For line trigger, the SOURCE switch is set to the LINE position, and the line frequency signal is fed to the trigger generator.

Internal Trigger

In the internal trigger mode, the trigger signal is internally obtained from the vertical deflection system, and even an input signal of very low amplitude is appropriately amplified to an adequate level for triggering. Therefore, panel control operation for this mode is very simple, and the chance that the comparatively low input impedance of the external trigger circuit may load the trigger signal source output is eliminated. From these advantages, it can be seen that internal triggering is generally convenient for measurement.

External Trigger

The shortcomings of external triggering are described under internal trigger operation, however, the external trigger operation still provides the following advantages.

First, the trigger generator is not influenced by the vertical deflection system. For example, the voltage level of the signal, which is fed to the trigger input in the internal trigger mode, varies when the position of the VOLTS/CM switch is changed.

These variations may necessitate readjustment of the LEVEL control every time the position of the VOLTS/CM switch is changed. Conversely, in the external trigger mode, the triggering is stable, once adjusted, regardless of variations in the vertical deflection system, except in the cases where the external trigger signal also varies.

Second, when it is desired to start the sweep a certain period in advance or after a certain time delay to display a particular point on the waveform, and provided that an appropriate triggering signal is available, the external triggering mode facilitates stable observation of the particular point. This external trigger signal should be connected to the TRIG INPUT connector.

When the SOURCE switch is set to the EXT position, and the amplitude of the external trigger signal is excessively large, proper adjustment of the trigger level with the LEVEL control may be impossible. In these case, trigger adjustment is facilitated by changing the SOURCE swigch to the EXT ÷ 10 position which attenuates the trigger signal by 10:1.

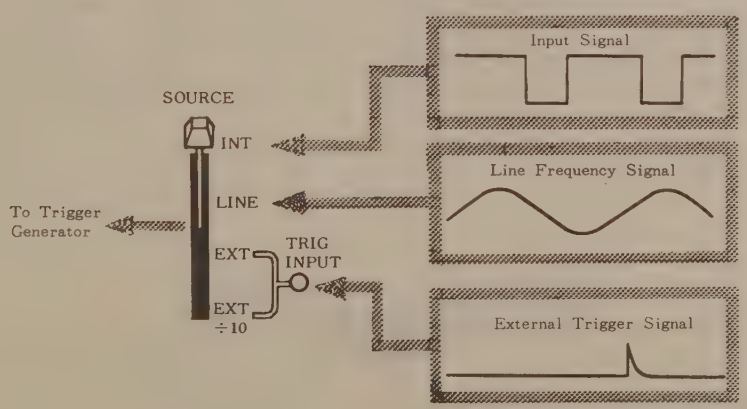
Line Trigger

In the LINE position of the SOURCE switch, the line frequency signal is connected directly from the power transformer to the trigger generator, and the sweep generator is stably triggered, neither influenced by the vertical deflection system as in the internal trigger mode, nor requiring complicated operation as in the external trigger mode.

Use Proper COUPLING switch

The COUPLING switch selects the coupling mode of the trigger signal and the trigger generator. Four coupling modes — AC, LF REJ, HF REJ, and DC — are available. In these modes, the trigger signal and the trigger input are

Figure 2–3 Selection of Trigger Signal with SOURCE switch



PROPER TRIGGERING

connected by a capacitor (AC), a high-pass filter (LF REJ), a low-pass filter (HF REJ), and directly (DC). The switch facilitates the selection of a suitable coupling method to provide stable triggering in accordance with the type of trigger signal (DC, AC waveform, AC waveform superimposed on DC, and low or high frequency noise on a waveform).

AC

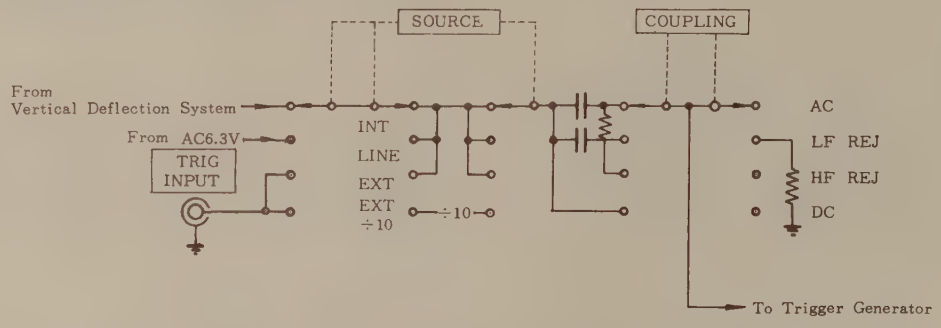
As shown in Figure 2–4, the trigger signal is connected to the trigger generator through capacitor coupling. The DC component in the trigger signal is blocked and only the AC component is used for triggering. This ensures stable triggering by eliminating the influence of the DC component.

The AC coupling is convenient for conventional measurement purposes, however, triggering sensitivity decreases at low frequencies (below 30 Hz) and triggering becomes less stable.

LF REJ

In this position, the trigger signal is fed to the trigger generator through a high-pass filter (refer to Figure 2–4) which blocks low frequencies (below approximately 30 kHz) or low frequency noise components superimposed on the trigger signal. Thus only the high frequency trigger signal triggers the sweep generator. This mode is used to provide stable triggering when measuring signals containing low frequency noise components like that shown in Figure 2–5. This paragraph should be typed underneath or at top of page.

Figure 2–4



HF REJ

In this position, the trigger signal is fed to the trigger generator through a low-pass filter, as shown in Figure 2–4. Contrary to the LF REJ position, high frequency signal (above approximately 50 kHz), or high frequency noise superimposed on the trigger signal, is bypassed. This coupling mode is convenient when using a trigger signal containing high frequency noise.

DC

As shown in Figure 2–4, the trigger signal is connected directly to the trigger generator in this position which enables triggering from a varying DC signal.

If an external trigger signal superimposed on a DC voltage is fed to the trigger input in the DC coupling mode, and the DC level exceeds the control range of the LEVEL control, the trigger signal can not trigger the sweep generator. AC coupling must be used in this case.

Figure 2–5

PROPER TRIGGERING

Selection of TRIGGER Switch

When the MODE switch is set to the ALT, CHOP, or ADDED position in the INT trigger mode, the TRIGGER switch selects the trigger signal source. When the TRIGGER switch is placed in the CH 1 position, the CH 1 input signal is fed to the trigger circuit, and in the CH 2 position, the trigger signal is supplied from CH2.

Therefore, if two signals of the same frequency are being simultaneously measured by CH 1 and CH 2, the TRIGGER switch should be set to the channel having the higher input level and least superimposed noise. When the frequency of the input signals fed to the two channels is different, the sweep circuit should be triggered by the channel having the lower frequency. Otherwise, the lower frequency signal will not be displayed. (Refer to Chapter 4 "Phase Measurement" for details.)

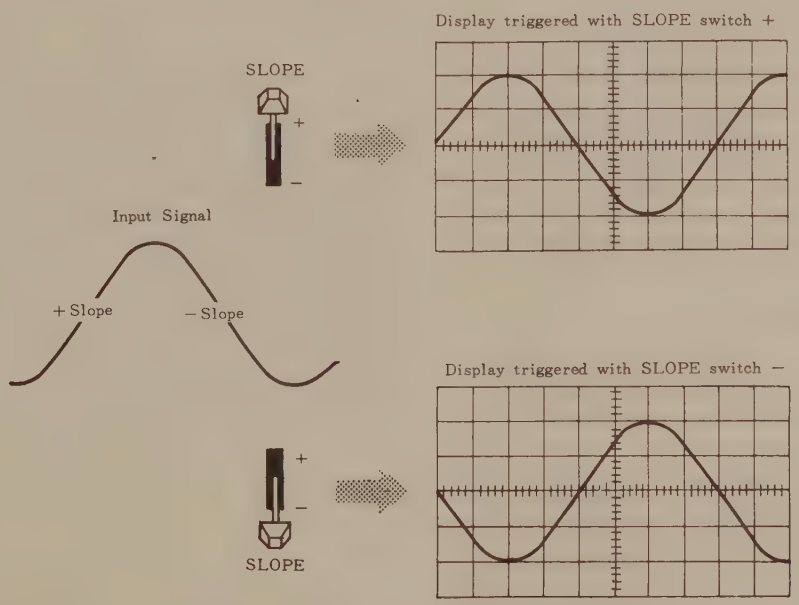
When the MODE switch is set to either CH 1 or CH 2, the TRIGGER switch is deactivated, and the display is triggered by the channel selected by the MODE switch. In other words, if the MODE switch is placed in the CH 1 position, the trigger circuit is triggered by the CH 1 input signal regardless of the position of the trigger switch.

Eliminating Trigger Jitter with HF STABILITY control

When the sweep is triggered by a signal higher than approximately 10MHz, trigger jitter may remain in the display even if the LEVEL control is set to the optimum point. This jitter can be eliminated by adjusting the HF STABILITY control.

This jitter may cause a double or triple display of an input signal at comparatively low frequencies of the trigger signal and synchronization will be lost at high frequencies of the same.

Figure 2–6 Selection of Trigger Polarity



Triggering Method (Auto Trigger)

The preceding control settings enable triggering by only adjusting the LEVEL control (A). Turn the LEVEL control (A) slowly; the display should be stably triggered at approximately the mid-position of the control. Vary the SLOPE switch (A) and adjust the LEVEL control as shown in Figure 2–7. The relationship between these controls and the display will be obvious.

Figure 2–7 shows an example of a sine wave, but the triggering point can be selected in the same manner for a square wave. A high sweep speed which provides a magnified display of the leading or falling edge will aid in the observation of the trigger point. The variable range of the trigger point is from 5 to 95 % of the slope height (for an internally triggered sine wave of approximately 1 kHz with a vertical amplitude of 6 cm on the graticule — the triggering range in the external trigger mode differs with the external trigger signal level).

Turn the CH 1 VOLTS/CM switch counterclockwise to reduce the display amplitude by approximately 2 mm. This decrease of display amplitude decreases the trigger signal level, and the triggering may be lost and the display may start free-running. Adjust the LEVEL control (A) again until the display is stable.

In the auto trigger mode, the display will free-run when the triggering signal is not present, or when the LEVEL control (A) is not set a the triggering point. Therefore, when a free-running sweep is desirable — for example, to confirm the vertical position of the ground potential (which is the reference level of the vertical display) — the AUTO position of the A SWEEP MODE is advantageous. It should be noted that the display will not be triggered in the AUTO mode by input trigger signals lower than 50 Hz. The following triggered mode should be used for triggering such low frequency signals.

Triggering Method (Normal Trigger)

When the A SWEEP MODE switch is placed in the NORM position, the normal trigger is used for triggering the sweep. The LEVEL control (A) must be adjusted similarly in this mode.

In this mode, however, when the trigger signal is not present, or the position of the LEVEL control (A) exceeds the triggering point, the sweep stops, and the display becomes a spot awaiting triggering (the spot may not be visible unless it is intensified by adjusting the INTENSITY control).

The preceding triggering operations are based on the internal triggering mode, however, these operations are identical for line triggering or external triggering, except the operation for the input trigger signal source.

▷ Dual Trace Operation and Addition or Subtraction of Two Signals

Dual Trace Operation

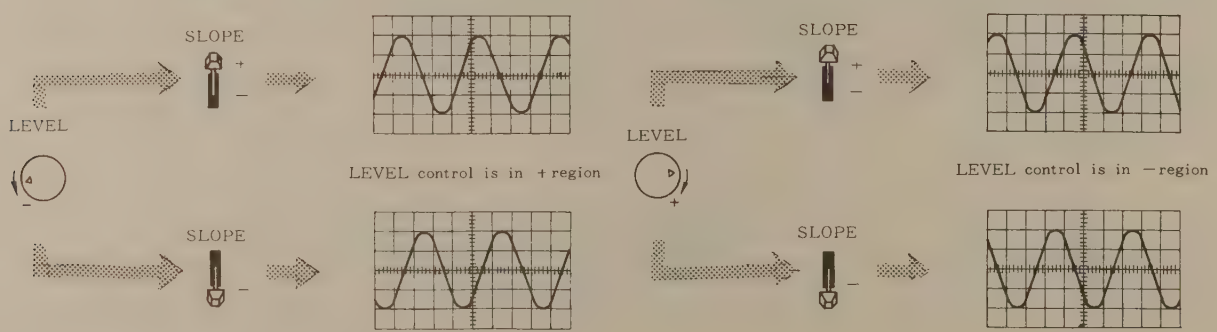
First, place the MODE switch in the ALT position. If the previously described control settings are retained, the calibrator output waveform is displayed at the CH 1 position and a trace (horizontal line) should appear at the CH 2 position. Both the CH 1 and CH 2 POSITION controls should be set to mid-range.

When the A TIME/CM switch is turned counterclockwise, the CH 1 and CH 2 outputs will be alternately displayed and simultaneous observation of the two displays becomes impossible. Dual trace measurement of low frequency signals which require slow sweep speeds of less than 2 msec/cm should be carried out in the CHOP mode as described below.

When the MODE switch is changed to the CHOP position, dual trace measurement at slow sweep speeds is possible. Contrary to the ALT mode, the CHOP mode is inconvenient for observation at sweep speeds above 5 μsec/cm as the waveforms will be displayed as dotted lines. Dual trace measurements of high frequency signals which require sweep speeds higher than 5 μsec/cm or dual trace measurement of fast rise (or fall) time signals should be performed in the ALT mode.

When dual trace measurement of different frequency signals (these signals must have a direct time relationship) is required, the TRIGGER switch must be properly set as previously described in "Proper Triggering". More stable triggering will be obtained in the CHOP mode by setting the COUPLING switch in the HF REJ position.

Figure 2–7 SLOPE and LEVEL



Sum or Difference of Two Signals

When the CH 2 POLARITY switch is changed to the NORM position, and the MODE switch placed in the ADDED position, the sum or difference of the CH 1 and CH 2 signals, will be displayed. When the CH 2 signal is inverted and added to the CH 1 signal. The difference between the two signals, or CH 1 + (—CH 2), is displayed.

In the ADDED position, the vertical position of the resultant waveform can be varied by either POSITION control, however, for accurate measurement, both POSITION controls should be set to mid-position.

▷ Cascade Connection Procedures

It is possible to increase the vertical deflection sensitivity up to 1 mV/cm with a cascade connection.

In the following example, the calibration voltage is used as an input signal. First, connect the CAL OUT connector and the INPUT connector for CH 2 with the jumper cable provided. Then set the following switches and controls as indicated.

MODE	CH 2
VOLTS/CM (CH 1, CH 2)	5 mV
VARIABLE (CH 1, CH 2)	CALIB position
CALIBRATOR VOLTS	5 mV

With the above switches in the specified positions, trigger the sweep. The display amplitude will be 1 cm, which is the normal vertical deflection sensitivity. Next, connect the INPUT connector of CH 1 and the CH 2 OUT connector with the coaxial cable provided (BB-500), and switch the MODE switch to CH 1. Now, the amplitude of the display will be 5 cm and the vertical deflection sensitivity, 1 mV/cm. The triggering will occasionally become unstable, but this will be stabilized by setting the COUPLING switch in the HF REJ position.

▷ Sweep Magnification

When a magnified display, with regard to time, of a particular part of a waveform is desired, the sweep speed may be increased. However, magnification by increasing sweep speed may drive the desired part out of the viewing area, unless the part is vary close to the starting point of the sweep.

By placing the MAG switch in the x10 position, the center portion of the display is magnified by 10 times, as shown in Figure 2–8. The trace length in the viewing area is approximately 10 cm, however, the unmagnified trace is now extended to 100 cm. The entire trace can be observed by rotating the POSITION and FINE controls.

The sweep time, when magnified, is 1/10 of the switch position indication, and the maximum sweep speed of 10 nsec/cm for an unmagnified trace, becomes 10 nsec/cm x 1/10 = 1 nsec/cm.

Magnification of the sweep with the MAG switch is advantageous to increase the maximum sweep speed, but it reduces sweep intensity and may cause confusion in calculating the time relation of the displayed waveform (the multiplication by 1/10 may be overlooked). It may be advisable not to use the magnified sweep except in the following cases.

(1) To magnify a particular point on the waveform which is a considerable distance from the starting point of the sweep.
(2) When a sweep speed higher than 20 nsec/cm is desired.

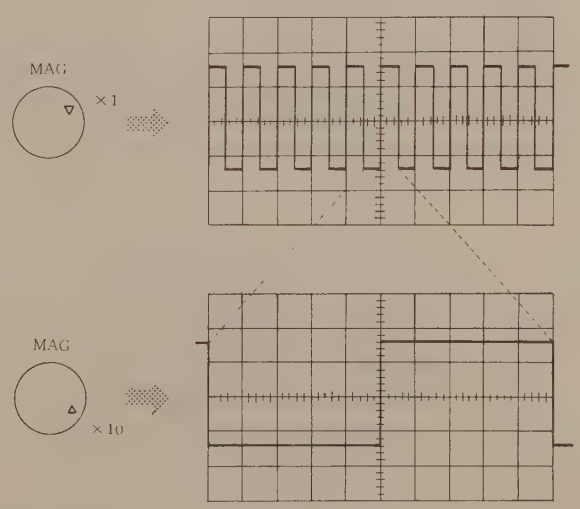
▷ Delayed Sweep Operation

Although sweep magnification with the MAG switch is simple to operate and magnify the rated TIME/CM by exactly 10, its magnification is limited in value.

Magnification of the display by the delayed sweep can extend the magnification factor up to the value determined by sweep times of the A and B sweep times. This magnification factor, however, is limited by the frequency of the given input signal. In other words, when the input signal of comparatively high frequency requires that the A TIME/CM switch be set to the maximum speed, or 20 nsec/cm, no further magnification is possible. Expansion with the delayed sweep is advantageous in expanding an optional portion of a comparatively low frequency signal.

The delayed sweep is classified into the non-triggered and triggered modes.

Figure 2–8 Sweep Magnification with MAG Switch



Non-Triggered Delayed Sweep

In the previous operations, various control have been set to various positions. Now, for ease of delayed sweep operation, the following rearrangement of control settings is required.

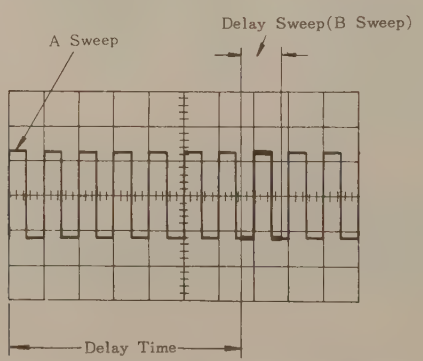
MODE	CH 1
VOLTS/CM (CH 1)	10 mV
VARIABLE (CH 1)	CALIB
CALIBRATOR VOLTS	50 mV
HORIZ DISPLAY	A
A SWEEP MODE	AUTO or NORMAL
A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
DLY'D(B) MODE	AUTO
SOURCE (A)	INT
COUPLING (A)	AC
SLOPE (A)	+
INTENSITY	Moderate spot brightness

Connect the CAL OUT connector to the CH 1 INPUT connector, and adjust the triggering for a stable display. Change the HORIZONTAL DISPLAY switch to the A INTEN BY B position, turn the locking lever of the DELAY TIME MULT dial to the left to release the dial, and slowly turn the dial clockwise. A portion of the display (delayed sweep part) will be intensified, as shown in Figure 2–9, and this intensified part will move toward the right with rotation of the dial. Any desired part of the A sweep display can be magnified in this manner. The width of the delayed sweep part is determined by the setting of the B TIME/CM switch and the B TIME/CM VARIABLE control (located on the right side panel).

Place the HORIZ DISPLAY switch in the DLY'D (B) position. The delayed sweep portion will be expanded to the full width of the viewing area, as shown in Figure 2–10. The expansion ratio is determined by the ratio of the A sweep time to the B sweep time. The displayed waveform can be moved horizontally by rotating the DELAY TIME MULTI dial. This dial allows any desired portion of a displayed waveform to be expanded and observed. The delay time is determined by multiplying the readings of the A TIME/CM switch and the DELAY TIME MULTI dial (For direct calibrated readings, set the A VARIABLE control to the CALIB position).

Change the B TIME/CM switch to the .2 μSEC position, and turn the DELAY TIME MULTI dial slowly until the leading or trailing edge of a square wave is displayed.

Figure 2–9 Non-Triggered Delay Sweep



Delay jitter (unstable horizontal trace) will appear as shown in Figure 2–11, and accurate evaluation of the leading or trailing edge will be difficult. This delay jitter restricts the upper limit of expansion. The expansion factor, however, can be increased by using the following triggered delay sweep method.

Triggered Delayed Sweep

Change the control settings as follows.

HORIZ DISPLAY	A INTEN BY B
A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
DLY'D (B) MODE	TRIG'D
SOURCE (B)	INT
COUPLING (B)	AC
SLOPE (B)	+

Turn the DELAY TIME MULTI dial more than one turn clockwise, and set the LEVEL (B) control to its mid-position. As shown in Figure 2–12 the delayed sweep part

Figure 2–10 Magnification of Non-Triggered Delay Sweep

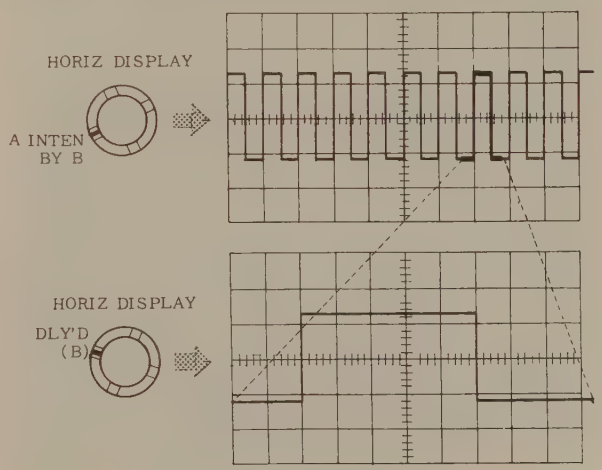
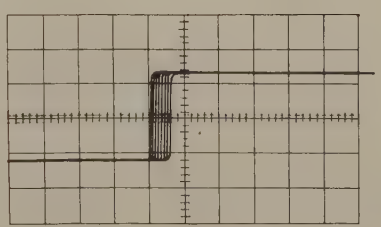


Figure 2–11 Delay Jitter



(intensified part) will be triggered at the rising edge of the A sweep. When the DELAY TIME MULTI dial is turned clockwise, the delayed sweep part will sequentially jump from one square wave (A sweep) to the next. Change the SLOPE (B) switch to the negative (−) position. The delayed sweep part will now be triggered at the trailing edge of the A sweep waveform. The delayed sweep, in this trigger mode, starts at the same point on the A sweep each time. The width of the delayed sweep part is also determined by the B TIME/CM switch and the B TIME/CM VARIABLE control.

Change the HORIZ DISPLAY switch to the DLY'D (B) position to expand the delayed sweep part to the full width of the display as shown in Figure 2–13. The expansion ratio is determined by the ratio of A sweep time to B sweep time. Change the B TIME/CM switch to the .2 μSEC position. Delay jitter should not appear. Therefore a higher ratio can be obtained in this mode compared to that of the non-triggered mode. The magnified waveform does not move when the DELAY TIME MULTI dial is rotated. In this method, the displayed waveform is a part of the delayed sweep portion, and expanded with respect to time by the B TIME/CM switch.

If the selected B sweep time is slower than the A sweep time, the B sweep part will not be displayed over the full trace width.

However, this is not a malfunction of the instrument. In practical operations, the B sweep time selected will be faster than the A sweep time, and this event will not occur.

Figure 2–12 Triggered Delay Sweep

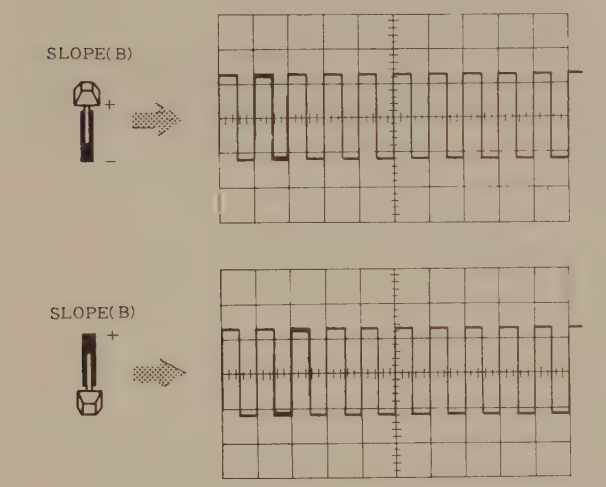
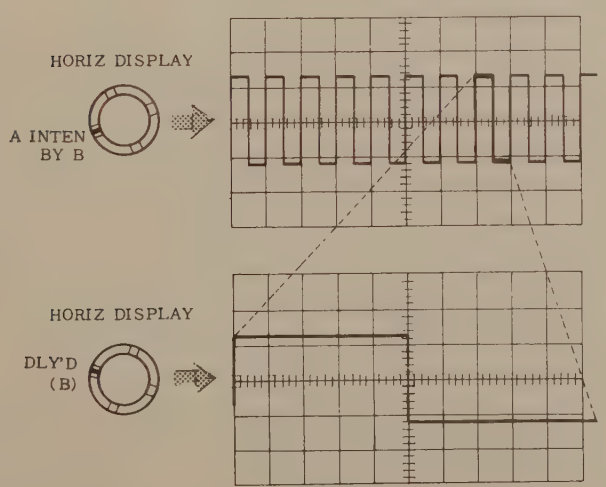


Figure 2–13 Magnification of Triggered Delay Sweep (B SLOPE switch +position)



▷ Single Sweep Operation

If a normal repetitive sweep is employed for observing a discharge waveform, chattering of relay contacts or other transient phenomena, the displayed waveform will appear to be doubled as shown in Figure 2–14. In such cases, the single sweep mode, by which the signal is swept only once, will display a correct waveform. Since the display is not repeated, the waveform is normally recorded by taking a photograph.

(IWATSU can supply a universal camera mounting which can be used for any type of camera.)

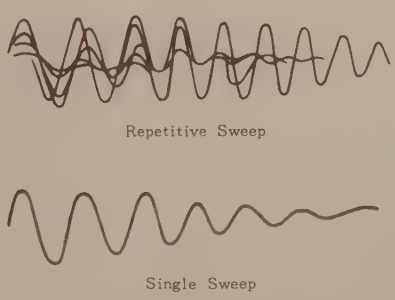
The single sweep operation will be explained by using the calibration signal as the input signal. Connect the calibration voltage to the input, and set the controls as follows.

HORIZ DISPLAY	A
A SWEEP MODE	NORM
VOLTS/CM	Suitable position for adequate display height
A TIME/CM	Any position for appropriate display

Adjust the triggering for a stable display and then change the A SWEEP MODE switch to the SINGLE position. The waveform will be displayed only once each time the RESET button is pressed down.

Remove the calibration signal cable from the INPUT connector, and press the RESET button. The circuit is now reset and in a waiting condition (to actuate a single sweep when a trigger signal is applied), and a lamp in the push-button lights to indicate this status. By connecting the calibration signal to the input, a single sweep is actuated.

Figure 2–14



The waiting status may not be obtained when the LEVEL control is close to its mid-position. In this case, adjust the LEVEL control slightly. Simultaneous observation of dual trace waveforms in ALT mode is impossible in the single sweep mode.

This single sweep is also possible in external triggering, in which connects trigger signal to TRIG INPUT connector in the same method as in the above internal triggering.

▷ XY Scope Operation

The basic operating procedure for XY scope measurements will be described, using the calibration signal as the input. First, place the controls in the positions indicated below.

INTENSITY	Fully clockwise
MODE	CH 1
HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
COUPLING (B)	AC or DC

After setting the switches and controls as stated above, rotate the POSITION control counterclockwise. A spot should appear. Connect the CAL OUT connector and the INPUT connectors (CH 1, CH 2) with the jumper cable Set the VOLTS/CM switches for CH 1 and CH 2 at the same positions and the CALIBRATOR VOLTS at a value which is five or ten times the indicated value of the VOLTS/CM switch. Two spots should appear on a diagonal of the viewing area. This is a Lissajous figure showing a frequency ratio of 1 : 1 and a phase difference of zero.

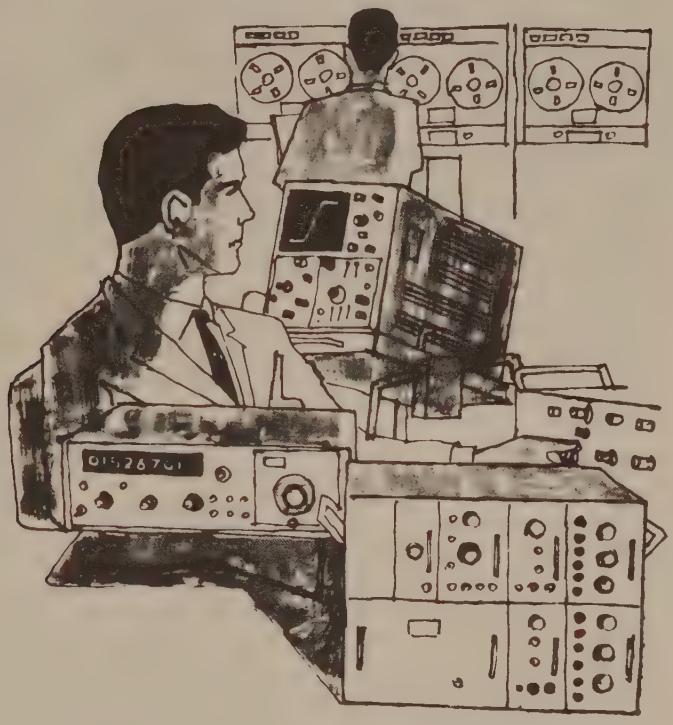
By feeding sine-wave inputs having different frequencies or different phase angles, various Lissajous patterns will be displayed. (Refer to Figure 3–15.)

XY scope operation is also possible by feeding one of the input signals to the TRIG OR HORIZ INPUT, and changing the SOURCE (B) switch to the EXT position.

By setting the COUPLING (B) switch to the AC or DC position, the signal fed to the TRIG OR HORIZ INPUT terminal is AC or DC coupled to the horizontal amplifier to deflect the electron beam horizontally.

The sensitivity of the horizontal axis is approximately 50mV/cm in the EXT position of the SOURCE (B) switch, and approximately 500mV/cm in the EXT ÷ 10 position.

CHAPTER 3. MEASUREMENT



Various measurement procedures and their application will be described in this chapter.

Refer to chapters 1 and 2 for technical characteristics and basic operating procedures of this instrument.

Connection of Input Signal 3- 2
Proper Use of Probe 3- 4
Voltage Measurement 3- 5
Current Waveform Measurement 3- 6
Time Measurement 3- 6
Frequency Measurement 3- 8
Phase Measurement 3- 9
Measurement of Non-Electrical Phenomena 3-10

▷ Connection of Input Signal

The input circuit of this instrument, viewed from the INPUT connector, is composed of 1 megohm of resistance and 14 pF of parallel capacitance. When the accessory probe (type 1018) is used, the resistance increases to 10 megohms and the capacitance decreases to 10 pF, thus reducing the influence of the oscilloscope on the circuit to be measured.

The signal to be observed may be connected to this equipment with conventional insulated wire, shielded cable, or coaxial cable. The type of cable should be selected considering the following conditions:

Output impedance of signal source
Amplitude and frequency of signal
Presence of external noise
Distance between equipment and signal source.

The preferable connection methods, classified in accordance with the type of input signal, are shown in Table 3–1.

Table 3–1

Type of Input Signal		Distance	Connection Method				
			Insulated wire	Shielded Cable	Probe	Coaxial Cable	Others
Low Frequency	Low Imp.	Short	○	○	○		
		Long		○		○	
	High Imp.	Short		○	○		
		Long		○			
High Frequency	Low Imp.	Short			○	○	
		Long				○	
	High Imp.	Short			○	○	
		Long					○

Connecting Signal with Conventional Insulated Wire

Using conventional insulated wire is simple and does not attenuate the signal to be measured. The conductor can be connected to the INPUT connector by using the adaptor (BNC-BP-12D) provided for this purpose.

However, if there is a considerable distance between the signal source and the oscilloscope and/or a magnetic field is present in the vicinity of the measuring cable, noise may be induced and affect the measurement. This induction is apparent when the impedance of the circuit to be measured is high.

Stray capacitance between a conventional insulated wire and ground is also considerably large, and the input capacitance viewed from the circuit to be measured becomes: (stray capacitance Cs) + (instrument input capacitance Co). The influence of this method on the circuit to be measured is greater than that of the probe (attenuation ratio 10:1).

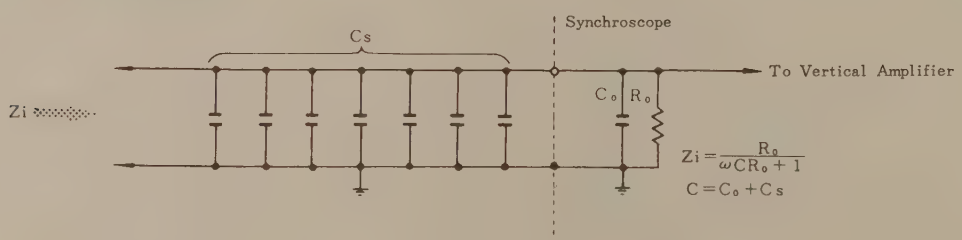
For example, assuming the output impedance of the signal source to be 1 kilohm with a frequency of 1 MHz and the input capacitance (stray capacitance of cable plus input capacitance of instrument) to be 100 pF, the signal source output is equivalently shunted by a resistance of 1.6 kilohms. At lower frequencies, the influence of the stray capacity decreases, for example, the equivalent resistance of the cable becomes 1.6 megohms at 1 kHz and the influence on the signal source is considerably reduced.

The use of conventional wire is suitable mainly for low frequency and low impedance measurements.

Use of Shielded Cables

The use of shielded cable protects the signal from externally induced noise, however, the large capacitance of this cable (from 50 pF/m to 100 pF/m) limits the use of shielded cable at high frequencies. Shielded cable is advantageous to eliminate the influence of static induction.

Figure 3–1 Input Impedance When Conventional Insulated Wire is Used



Use of Probe

When the accessory probe (attenuation ratio is 10:1) is used, the influence of external induction is also eliminated since the input cable is shielded as shown in Figure 3–2. In addition, the wide range attenuator composed of attenuating resistor Rp, compensation capacitance Cp, the instrument input resistor Ro and stray capacitance Co, ensures accuracy in measuring impedance or high frequency signal sources. Since the input capacitance of the probe (viewed from the probe tip) is approximately 10 pF, the input impedance of the probe is approximately 16 kilohms at 1 MHz and is comparatively higher than that in the previously described method.

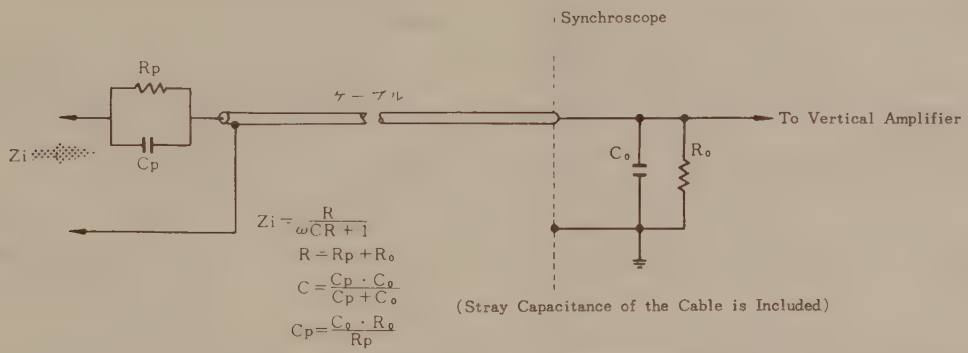
However, the probe has some disadvantages as the input signal is attenuated by 1/10, and the cable length is restricted. The IWATSU source follower probe decreases input capacitance without attenuating the signal amplitude. (Refer to "Associated Equipment and Accessories.")

Use of Coaxial Cable

When the output impedance of a signal source is 50, 75, 93 or 125 ohms, the use of coaxial cable with the same characteristic impedance will enable high frequency signals to be coupled without attenuation.

It should be noted that the coaxial cable must be properly terminated at the instrument side to avoid distorting high frequency signals.

Figure 3–2 Input Impedance of Probe



Other Methods

For accurate measurement of remote signal sources having high frequency and high impedance, an impedance converter must be used to match the circuit impedance to that of the coaxial cable (75 ohms, for example) which is used to connect the signal to the instrument. A transformer may be used for a narrow bandwidth measurement, but a cathode follower or similar circuit is preferred for wide band measurements. (Refer to Figure 3–4)

When the output level from the measured circuit is high, the input signal to the vertical amplifier may be voltage-divided by a divider (R) of which output impedance is matched to the coaxial cable impedance, as shown in Figure 3–5.

Figure 3–3 Signal Coupling Using Coaxial Cable

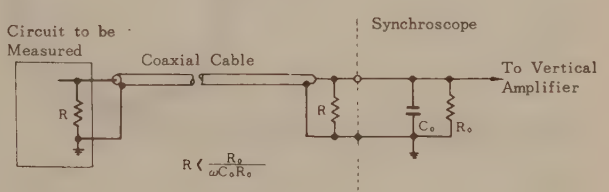


Figure 3–4 Coupling A Remote Signal Source (1)

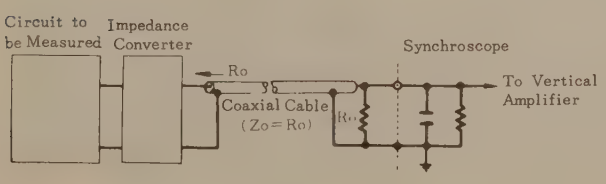
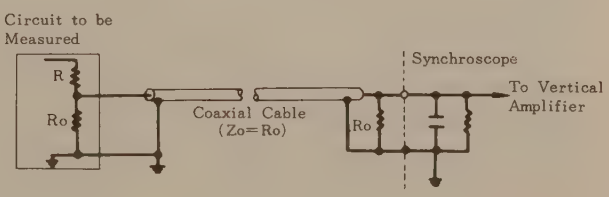


Figure 3–5 Coupling a Remote Signal Source (2)



▷ Proper Use of Probe

Probe Phase Caribration

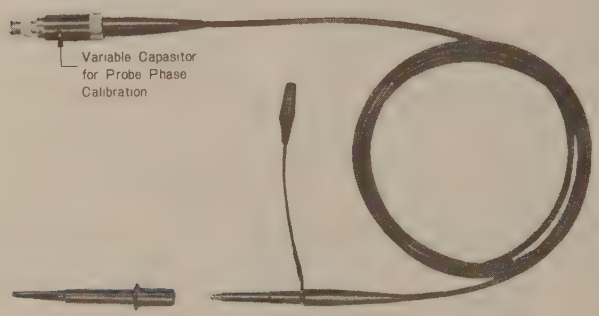
The phase characteristics of the probe must be correctly adjusted to avoid erroneous measurement. Remove the pointed tip of the probe and connect this end of the probe to the CAL OUT with the opposite end of the probe cable connected to the INPUT connector. Set the VOLTS/CM switch to the 10 mV position and set the CALIBRATOR VOLTS switch to the 0.2 or 0.5 position to obtain a display with an amplitude of 2 cm or 5 cm.

By adjusting the trimmer capacitor in the probe, Figure 3–6, the flatness of the displayed waveform can be varied as shown in Figure 3–7. Set the trimmer for the sharpest square waveform.

Once the probe phase is adjusted in the 10 mV range, it should also be correct in other positions of the VOLTS/CM switch. If the phase characteristics differ with different positions of the VOLTS/CM switch, adjust the attenuator compensators referring to the item entitled "VOLTS/CM Switch Phase" in Chapter 6.

Avoid adjusting the probe phase in the 5 mV position since external noise may be induced in this position.

Figure 3–6 Probe



Precautions on Use of the Probe

If the probe ground lead is connected to the signal source ground when measuring a wave having a fast rise or fall time, it may cause ringing or other distortion in the displayed waveform. For measurements of this type, the bayonet adaptor (Figure 3–6) should be used to red ce the possibility of this type of distortion.

Probe Accessories

For effective use of the probe, various accessories are provided as shown in Table 3–2.

Table 3–2

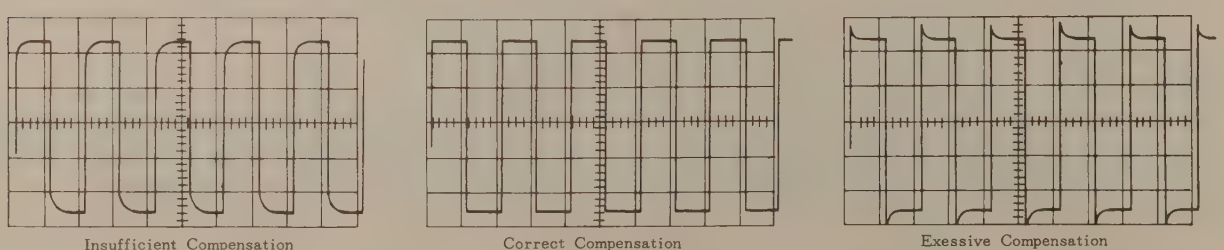
Accessories	Purpose
Protection Cap	Protects probe tip from damage when the probe is not being used.
Hook Tip	Enables the probe to be hooked to the object be measured.
Bayonet Adaptor	Used to connect the probe ground close to the point being measured. Prevents wave-from distortion when measuring waveforms having fast rise or fall times.
Insulator Tube	Prevents the probe tip from contacting circuits adjacent to the point being measured.
Probe Hook	Used to fasten the probe head to the connector of the probe.

Precautions on Use of Source Follower Probe

The SFP-1 Source Follower Probe facilitates non-attenuated (1:1) wide frequency range measurements.

If this probe is connected to the oscilloscope while the power is ON, the low voltage supply circuit for the probe may be damaged. BE SURE the power is OFF before the probe is connected. (Refer to "Instruction Manual for SFP–1" for details of the probe.)

Figure 3–7 Probe Phase and Output Waveform



Insufficient Compensation | Correct Compensation | Exessive Compensation

▷ Voltage Measurement

Quantitative Measurement

For direct reading of voltage values in quantitative measurements, the VARIABLE control must be set to the CALIB position. However, quantitative measurement of waveform amplitude is also possible with the VARIABLE control in a position other than CALIB.

(1) Determine the vertical amplitude of the display on the graticule.

(2) Connect the calibration voltage (CAL OUT) to the INPUT and adjust the CALIBRATOR VOLTS switch to obtain a display amplitude comparable to the previously displayed signal amplitude. Do not change the CALIBRATOR, position control, VOLTS/CM or the VARIABLE control. The vertical deflection sensitivity at these control positions is then calculated from the following equation.

$$\text{Vertical deflection sensitivity (V/cm)} = \frac{\text{indication of CALIBRATOR VOLTS switch (V)}}{\text{displayed amplitude of CALIB voltage (cm)}} \quad \text{.....(3–1)}$$

The signal amplitude is calculated from the following equation (3–2).

$$\text{Input signal voltage (V)} = \text{vertical deflection sensitivity (V/cm)} \times \text{displayed amplitude (cm)} \quad \text{.....(3–2)}$$

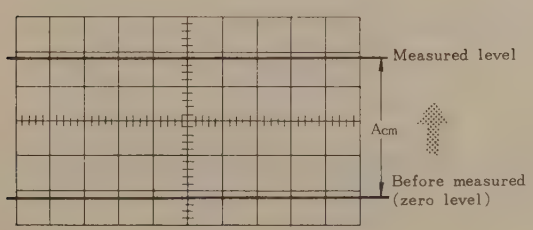
DC Voltage Measurement

This instrument can also be used as a DC voltmeter. First, obtain a trace in the free run mode and select a fast sweep time so that the trace will appear steady.

Turn the AC-GND-DC switch to the GND position, (vertical position of the trace now represents zero volts at the input as shown in Figure 3–8). Adjust the vertical position to place the trace on a horizontal graticule line. Change the AC-GND-DC switch to the DC position, and measure the input signal amplitude. Observe the distance between the displayed signal level and the zero level line.

If the signal level is displayed beyond the viewing area, reduce the vertical deflection sensitivity, and repeat the zero level setting and the input signal measurement.

Figure 3–8 DC Voltage Measurement



When the signal level is displayed above the zero level, the polarity of the input signal is positive (+), and a negative (–) voltage is displayed below the zero level line. Letting the distance between the two lines represent A (cm), the input voltage can be calculated as in equation (3–3) or (3–4).

When the 10:1 probe is used for measurement:

$$\text{1/10 of Voltage (V)} = \text{VOLTS/CM switch value (V/cm)} \times \text{displacement of trace level (A cm)} \quad \text{.....(3–3)}$$

When the voltage to be measured is connected directly to the INPUT,

$$\text{Voltage (V)} = \text{VOLTS/CM switch value (V/cm)} \times \text{displacement of trace level (A cm)} \quad \text{.....(3–4)}$$

AC Voltage Measurement

If an AC signal superimposed on a DC voltage with an amplitude larger than that of the AC signal is measured while the AC-GND-DC switch is in the DC position, the AC component may be displayed out of the viewing area. The AC waveform can be returned to the viewing area of the graticule by adjusting the POSITION control, but this may result in erroneous measurements. The AC portion may also be measured by reducing the vertical deflection sensitivity, but this reduces the accuracy of the measurement.

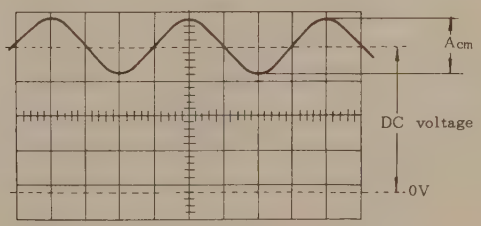
The AC position of the AC-GND-DC switch should be used for these purposes. By using the AC position, the DC component of the input signal is blocked by the coupling capacitor, and the AC portion can be displayed at an amplitude which provides sufficient measuring accuracy. The absolute value of the AC signal amplitude is calculated from equation (3–3) or (3–4).

(It should be noted that the displayed amplitude of an AC signal is attenuated by 3 dB at approximately 3 Hz in the AC mode. When the probe is used, the attenuation is 3 dB at approximately 0.3 Hz.)

The AC signal amplitude calculated from equation (3–3) or (3–4) represents the peak to peak value, and the effective value (Vrms) of a sine wave is found as

$$\text{Effective voltage (Vrms)} = \frac{\text{Volt (p–p)}}{2\sqrt{2}} \quad \text{.....(3–5)}$$

Figure 3–9 AC Signal Superimposed on DC Voltage



▷ Current Waveform Measurement

CRT oscilloscopes, including synchroscopes, display only the voltage of given signals. Electrical phenomena other than voltage, and mechanical vibrations or other physical phenomena must be converted into voltage variations before they can be measured.

Current can be measured by reading the voltage drop across a resistor of known value inserted in the circuit being measured. The current is then calculated with Ohm's law, E=IR. The value of a resistor inserted in the circuit must be sufficiently small so as not to change the characteristics of the circuit being measured.

When a resistor can not be inserted in the circuit, the current probe facilitates current measurement without disconnecting the circuit. (Refer to "Associated Equipment and Accessories.")

When the circuit being measured is isolated from ground, as shown in Figure 3–10, correct current measurement with a conventional single input instrument is impossible. In other words, a differential amplifier is required.

As described in "Dual Trace Measurement and Sum or Difference of Two Frequencies" in Chapter 3, this instrument is provided with a differential measurement function.

For this function, set the MODE and CH 2 POLARITY to the ADDED and INV positions respectively, and connect the probe tips of the CH 1 and CH 2 inputs to the ends of resistor r. By setting the VOLTS/CM switches of CH 1 and CH 2 to an identical voltage range, the waveform across resistor r, or the current waveform, can be read directly.

▷ Time Measurement

Measurement of Time Interval

The time interval between two selected points on a waveform can be read directly by setting the VARIABLE control to the CALIB position and reading the horizontal distance between the points from the graticule.

Change the HORIZ DISPLAY switch to the A position, and set the A VARIABLE control to the CALIB position. Trigger the display and set the A TIME/CM switch to a position which facilitates reading of the distance. The time interval (T) between the two points is calculated as:

T (sec) = TIME/CM switch value (sec/cm) x distance between the points on the graticule (cm) x reciprocal of MAG switch value ..... (3–6)

The reciprocal of the MAG switch value is 1 when the display is not magnified and 0.1 when magnified.

▷ Difference of Time Between Two Signal

The time difference between two signals is easily measured by using the ALT, CHOP, or ADDED mode of this instrument. Figures 3–12 and 3–13 respectively show examples of these measurements.

In these modes, the display must be triggered by the leading signal with regard to time, or the TRIGGER switch must be set to the channel displaying the leading signal.

Read the distance T from the graticule, and calculate the time from equation (3–6).

Figure 3–10

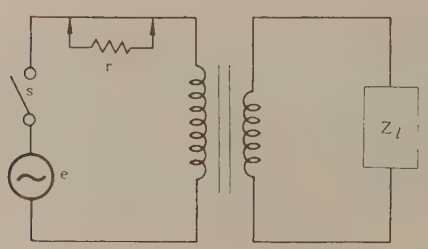


Figure 3–11 Time Interval Measurement

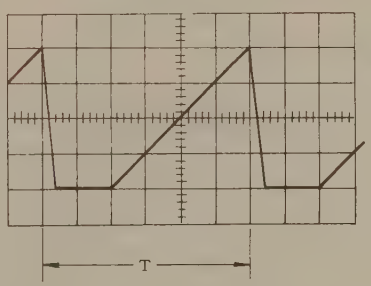
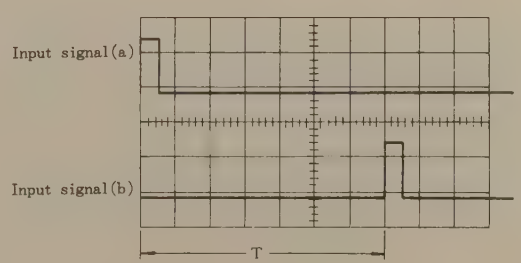


Figure 3–12 Time Difference Measurement in ALT or CHOP Mode



Measurement of Leading (or Trailing) Edge of Waveform

The signal delay cable provided in the vertical amplifier facilitates internally triggered measurements of the rising (or falling) point of the leading edge of a waveform (shown in Figure 3–4) as long as the rise (or fall) time of the waveform is faster than the signal delay time of 90 nsec.

When the rise (or fall) time of a waveform is slower than the signal delay time, the display must be externally triggered.

Pulse Width Measurement

Pulse width is measured as follows.

Adjust the vertical position and amplitude of the display so that the pulse height is equal both above and below the center horizontal line of the graticule (set total height to 2 cm or 4 cm). Turn the VARIABLE control fully clockwise and set the TIME/CM switch to a position which allows easiest reading of the display. Read the distance between the centers of the leading and the trailing edges (T), (or crosspoints of these edges and the center horizontal line) from the scale on the horizontal graticule line. The pulse width is calculated from equation (3–6). Magnify the horizontal display if the pulse width is very narrow.

Measurement of Rise (or Fall) Time of Pulse

Set the vertical and horizontal position and amplitude controls as in the pulse width measurement. Move the pulse display horizontally so that the upper 10 % (4 mm in the example, since the pulse height is 4 cm) of the leading edge crosses the vertical center line of the graticule, and read the distance (T_1) between the point where the vertical leading (or trailing) edge of the pulse crosses the horizontal center line, and the vertical center line of the graticule. Adjust the POSITION control to move the lower 10 % of the leading edge so it crosses the vertical center line. Read the distance T_2. Substitute the value $T_1 + T_2$ in equation (3–6) to obtain the pulse width T (sec).

Figure 3–13 Time Difference Measurement in ADDED Mode

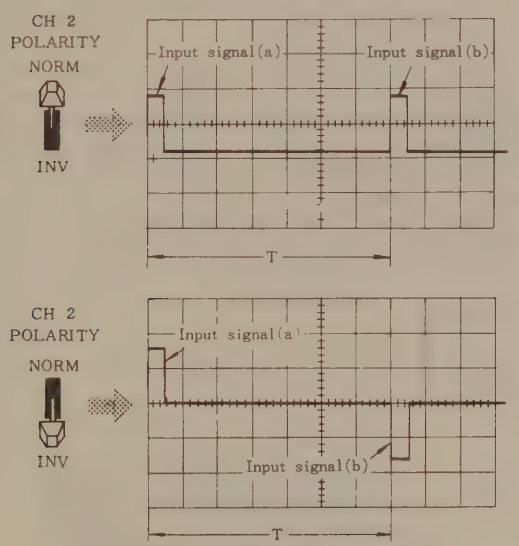
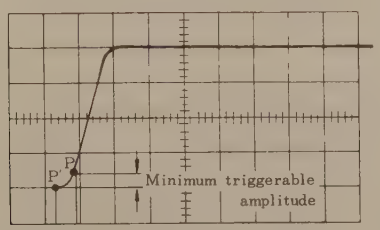


Figure 3–14



In the absence of signal delay cable, sweep start at P.

When a signal delay cable is incorported, the sweep start at P'.

Figure 3–15 Pulse Width Measurement

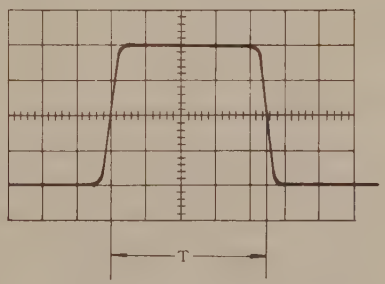
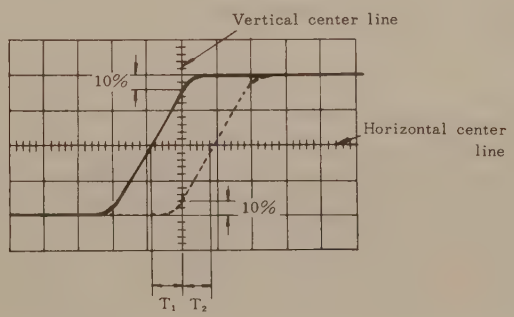


Figure 3–16 Rise (or fall) Time Measurement



Direct reading of the pulse width is possible only when the rise (or fall) time of the pulse is sufficiently slower than the rise time of this instrument. If a pulse having a very fast rise time is measured, the result (T) obtained from equation (3–6) must be corrected by the following equation (3–7).

$$Tr = \sqrt{T2 - Ts2} \quad \text{.....(3–7)}$$

where Tr: True value of pulse width
T: Measured value
Ts: Rise time of this instrument

▷ Frequency Measurement

Frequency measurements can be largely classified into three types.

First, the frequency can be calculated from the time per cycle (equation 3–6) obtained as shown in Figure 3–17, and equation (3–8).

$$\text{Frequency f (Hz)} = \frac{1}{\text{Time T (sec)}} \quad \text{.....(3–8)}$$

In Figure 3–7, the length of one cycle is 8 cm and the TIME/CM switch is in the 1 μsec/cm position. Thus, the time T is,

$$T \text{ (sec)} = 8 \text{ cm} \times 1 \text{ μsec/cm} = 8 \text{ μsec}$$

Therefore, the frequency f (Hz) is,

$$f \text{ (Hz)} = 1/8 \times 10^{-6} \text{ sec} = 125 \times 10^{3} \text{ (Hz)} = 125 \text{ kHz}$$

Second, the frequency can be calculated from equation (3–9) by counting the number of cycles (N) displayed in the horizontal scale (10 cm).

$$\text{Frequency f (Hz)} = \frac{N}{\text{TIME/CM switch value} \times 10} \quad \text{.....(3–9)}$$

This method is more accurate than the former method, and absolute accuracy of measurement approaches that of sweep time, provided that the number of cycles, N, is sufficiently large (30 to 50). When N is comparatively small, reading the value of N below the decimal point becomes uncertain, and accuracy decreases.

These frequency measurement methods are based upon time measurement. When the frequency of the waveform to be measured is comparatively low (below 100 kHz) and its waveform is a simple sine, square, triangular, or sawtooth, the frequency may be measured by using the instrument as an XY scope to display a Lissajous pattern, as described in Chapter 2.

Set the HORIZ DISPLAY and the SOURCE switches respectively to the EXT and the INT positions. Select the AC-GND-DC switch position in accordance with the type of input signal. Feed the signal to be measured (assumed to be a sine wave signal) to CH 1 INPUT, and connect the CH 2 INPUT to a signal source of a known frequency (calibrated signal generator). Set both the vertical and horizontal amplitudes to approximately 4 cm.

Vary the signal generator frequency to obtain a Lissajous pattern for a frequency ratio of 1:1, as shown in Figure 3–19. The Lissajous pattern for 1:1 is either a circle, ellipse, or a straight line. When the frequency ratio approaches 1:1, the pattern continuously varies from a → b → c → d → e → d → c → b → a, and repeats this variation. As the frequency ratio becomes closer to 1:1, the above variation subsides, and finally the pattern stops varying and one of the below waveforms will be displayed.

The signal generator frequency at which the pattern becomes stable represents the frequency of the signal being measured, and the accuracy of the measurement is equal to that of the signal generator.

The number of pattern rotations per second, (from a to a) represents the difference between the two frequencies. The approximate relation of the measured frequency to the standard frequency — lower or higher than the standard — can be easily determined by slightly changing the signal generator frequency.

These events dictate that frequency measurements using a Lissajous pattern must be carried out for a sufficiently long period, particularly for low frequencies, (for example 1 Hz or 10 Hz) to confirm that the pattern will not vary in this period.

Figure 3–17 Frequency Measurement (1)

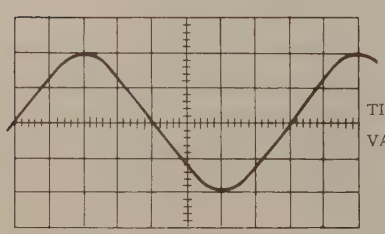


Figure 3–18 Frequency Measurement (2)

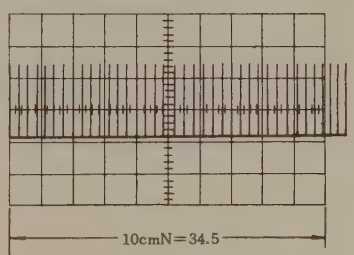


Figure 3–19 Lissajous Pattern of Sine Waves

Lissajous patterns for sine-wave signals having different frequency ratios are shown in Figure 3–20. The pattern for an optional frequency ratio may be determined by geometric drawings, however, the 1:1 pattern method using a variable frequency signal generator is the simplest and most accurate.

Figure 3–21 shows the Lissajous pattern for different waveforms.

▷ Phase Measurement

Measurement with Lissajous Pattern

Phase difference between two signals can be calculated from equation (3–10) by substituting values A and B obtained from the Lissajous pattern.

$$\text{Phase difference angle} = \sin^{-1}\frac{A}{B} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(3–10)}$$

This method is, however, restricted to frequencies below 100 kHz due to phase distortion in the instrument at higher frequencies.

Phase Measurement by Dual Trace Operation (When The Two Frequencies are Equal)

Figure 3–23 shows an example of a phase difference measurement between two sine waves.

For this method, the TIME/CM switch and the VARIABLE control are set so that one cycle of the signal is displayed in exactly 9 cm. One vertical division (1 cm) represents 40° —— since one cycle = $2\pi = 360^{\circ}$ is displayed in 9 divisions, and the phase difference between the signals is calculated by equation (3–11).

Phase difference (degree)
= Horizontal distance between the two signals on the graticule (T) x 40° ..... (3–11)

Figure 3–20 Lissajous Patterns for Various Frequency Ratios

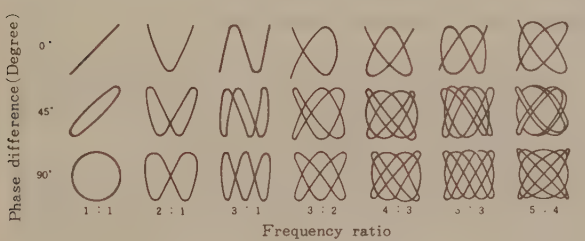


Figure 3–21 Lissajous Patterns for Different Waveforms (Frequency Ratio 1 : 1)

(a) Sine Wave and Triangular Wave (b) Sine Wave and Square Wave (c) Sine Wave and Sawtooth Wave

Figure 3–22 Phase Measurement with Lissajous Pattern

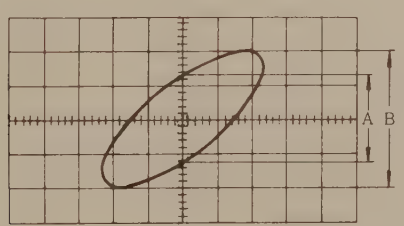


Figure 3–23 Phase Measurement of Two Signals of the Same Frequency

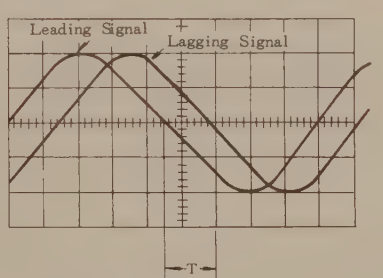
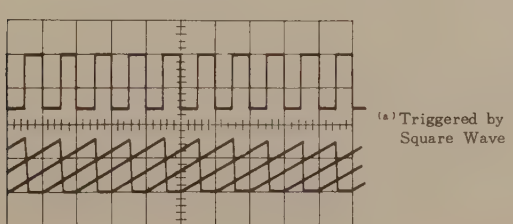
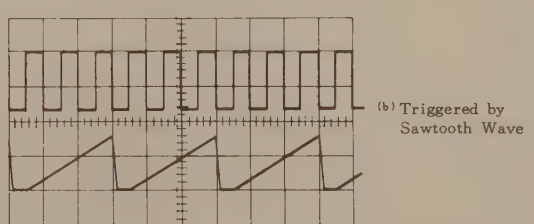


Figure 3–24 Phase Measurement of Two Signals of Different Frequencies



(a) Triggered by Square Wave



(b) Triggered by Sawtooth Wave

Dual Trace Measurement of Signals of Different Frequencies

Figure 3–24 shows an example of a pulse shaper output and a sawtooth wave triggered by this pulse. To measure the phase difference of two signals having different frequencies (provided the frequency ratio is an integer), the sweep must be triggered by the lower frequency signal. If the sweep is triggered by the higher frequency signal (square wave in this example), the sawtooth wave signals will not be triggered properly.

▷ Measurement of Non-Electrical Phenomena

Voltage is the only phenomenon which can be measured directly, on a synchroscope. Synchroscopes, however, are widely used for measuring phenomena other than voltage as a result of the development of transducers which convert these phenomena into voltage. Transducer type measurements are now practiced in various fields such as kinetics, optics, temperature, and chemistry.

A summary of typical transducers is described in the following paragraphs.

Measurement of Kinetic Variation

The following properties of material under external force are employed to convert kinetic variations such as displacement, distortion, pressure, or vibration, into electrical variations.

(1) Resistance variations of wire resistors and semiconductors due to externally applied force. These devices are known as strain gages.

(2) Piezoelectric elements such as quartz crystals or barium titanate which produce an electrical output proportional to an externally applied force.

(3) Capacitance pick-up which varies its internal capacitance in accordance with an externally applied force.

(4) Ferromagnetic pick-up which varies its magnetic properties with external force.

(5) Electromagnetic pick-up. Converts displacement into electromagnetic force.

Various other types of transducers are also produced. All these transducers are attached either directly or through an adequate material to the object being measured.

These transducers may be classified according to their purpose, such as distortion measurement, pressure, or vibration, etc. These devices can be further classified into types which operate at high temperature or humidity, high frequency, large amplitude vibration, and those which are extremely sensitive for minute vibrations, etc.

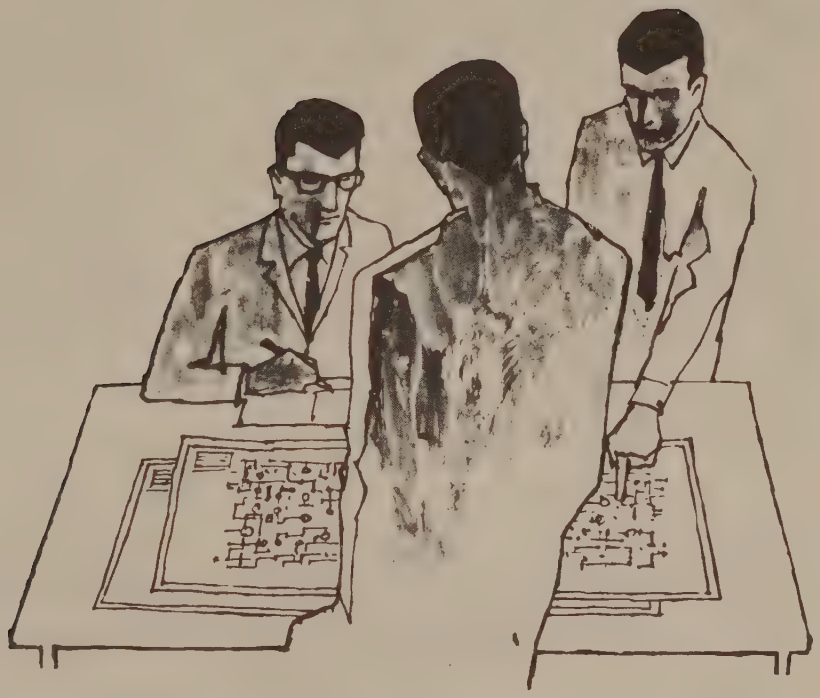
Various new transducers are being developed, and additional applications using synchroscopes for measuring physical properties are expected.

Optical and Temperature Measurement

Transducers which convert light variations into electrical variations are commonly known as photoelectric cells and phototransistors. Photomultiplier tubes are used for detecting very dim or minute changes of light.

Thermistors, of which electrical resistance varies with temperature, and thermocouples composed of two dissimilar metals which generate an electromotive force when their junction point is heated, are the most commonly used thermal transducers.

CHAPTER 4. CIRCUIT DESCRIPTION



The operation of individual circuits is described in this chapter to aid in the maintenance and calibration of this instrument.

The overall operation is described first, using the block diagram in Figure 4—1. A detailed description of individual circuit operation follows.

General ..... 4— 2
Circuit Description ..... 4— 3
Vertical Input and Attenuator ..... 4— 3
CH 1 Preamplifier ..... 4— 4
CH 2 Preamplifier ..... 4— 4
Switching Circuit ..... 4— 5
Vertical Main Amplifier ..... 4— 6
Trigger Amplifier ..... 4— 7
A Trigger Generator ..... 4— 8
A Sweep Generator ..... 4—12
B Trigger Generator ..... 4—16
B Sweep Generator ..... 4—18
Horizontal Preamplifier ..... 4—20
Horizontal Main Amplifier ..... 4—20
Unblanking Amplifier ..... 4—22
Blanking Amplifier ..... 4—23
CRT Circuit ..... 4—23
Low Voltage Power Supply ..... 4—24
Calibrator ..... 4—26

▶General

Circuit configuration of this instrument is shown in Figure 4–1. Each block operates, as the final purpose, to deflect the electron beam of the CRT.

Two independent preamplifiers are provided for the vertical amplifier system. The input signal is connected to the INPUT connector, then amplified and converted into a balanced signal and fed to the switching circuit.

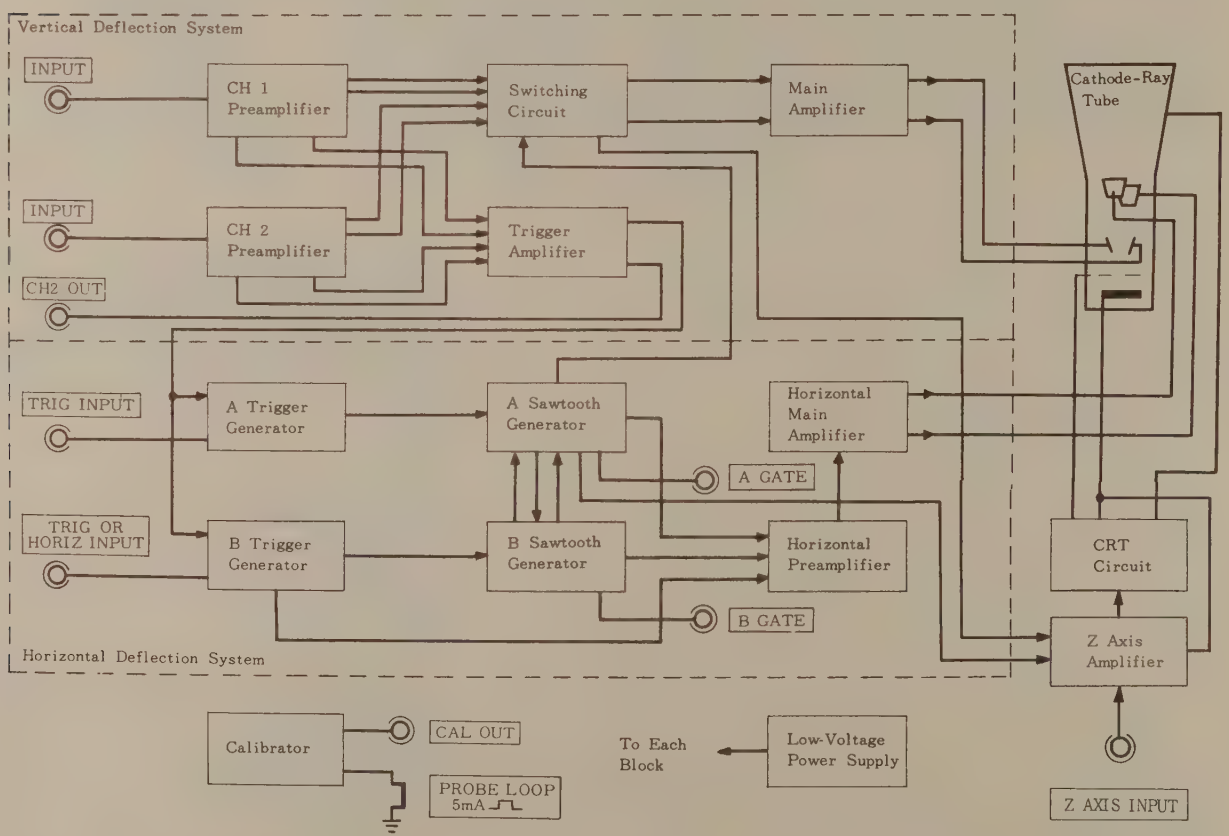
A diode gate in the switching circuit determines the connection of the input(s) (CH 1, CH 2 or both) to the main amplifier. The MODE switch selects either CH 1, CH 2, the algebraic sum of the two signals (ADDED), or the two signals electronically switched (ALT or CHOP). In the ALT position of the MODE switch, the diode gate is switched by a trigger signal from the sweep generator, and the CH 1 and CH 2 signals are alternately displayed as complete sweeps. In the CHOP mode the two signals are chopped, regardless of the sweep rate, at a repetition rate of approximately 1 MHz. In this mode, the switching waveform (chop blanking pulse) is supplied to the blanking amplifier to blank transients of the switching.

The main amplifier functions to amplify the balanced signal up to a sufficient level to deflect the electron beam of the CRT.

The signal fed to the INPUT connector is also internally fed to the trigger amplifier where it is amplified and fed to the A and B trigger generators. The signal fed to the CH 2 INPUT is amplified by 5 times and supplied to the CH 2 OUT connector.

The A and B trigger generators convert the trigger signal into a trigger pulse having a constant amplitude and pulsewidth. The trigger pulse may also be generated by an external trigger signal or line frequency signal supplied to the TRIG INPUT (TRIG OR HORIZONTAL INPUT) connector. The A sweep generator is triggered by the A trigger generator, and the B sweep generator by the B trigger generator. The A and B sweep generators are interconnected for delayed sweep operation. Three types of interconnection are provided; the A → B connection for the delay sweep, the A → B connection to control the width of the intensified part of the display in the A INTEN BY B mode, and the B → A connection to intensify the display in delayed sweep operation. Moreover, the gate

Figure 4–1 Basic Block Diagram



signal from the B sweep generator is fed to the unblanking mixer of the A sweep generator, from which either the A or B unblanking signal or the mixed unblanking signals (when the HORIZ DISPLAY switch is set at A INTEN BY B) are supplied to the Z axis amplifier. Also, the gate signals are produced and fed to the A GATE and B GATE connectors, respectively.

Two methods of operation are provided for the XY scope function. In either case, the Y axis input signal is fed to the CH 1 input and eventually to the vertical deflection plates. The X axis signal may be fed to CH 2 INPUT or to the TRIG OR HORIZ INPUT. In the first method, the input signal is fed to the horizontal deflection plates through the CH 2 preamplifier, trigger amplifier, a part of the B trigger generator, and the horizontal amplifier. In the latter method, the input signal is fed to the horizontal deflection plates through a part of the B trigger generator and the horizontal amplifier. A Lissajous pattern is then formed by the X and Y signals.

The Z axis amplifier amplifies the unblanking signals from the A sawtooth generator, the chop blanking signals from the switching circuit, and external intensity modulation signals applied to the Z AXIS INPUT terminal: The INTENSITY control, part of X axis amplifier, controls the intensity of the CRT display by varying the reference level of the output signals.

The output signals are supplied to the control grid of the CRT, through a portion of the CRT circuit.

The CRT circuit produces the high voltage required to emit and accelerate the electron beam.

The 6.3 V AC used for the CRT filaments and graticule illumination lamps, and the low DC voltages required for the operation of circuits are obtained from the low voltage power supply.

The calibration voltage and current supply produces the calibration voltage used for the calibration of internal circuit and the voltage probe, as well as the calibration current for the current probe.

▶Circuit Description

The operation of each circuit will be described using the block and circuit diagrams as references.

Circuits which consist of similar configurations (i.e. CH 1 and CH 2 preamplifiers,) are collectively described, and any differences between the two circuits are explained.

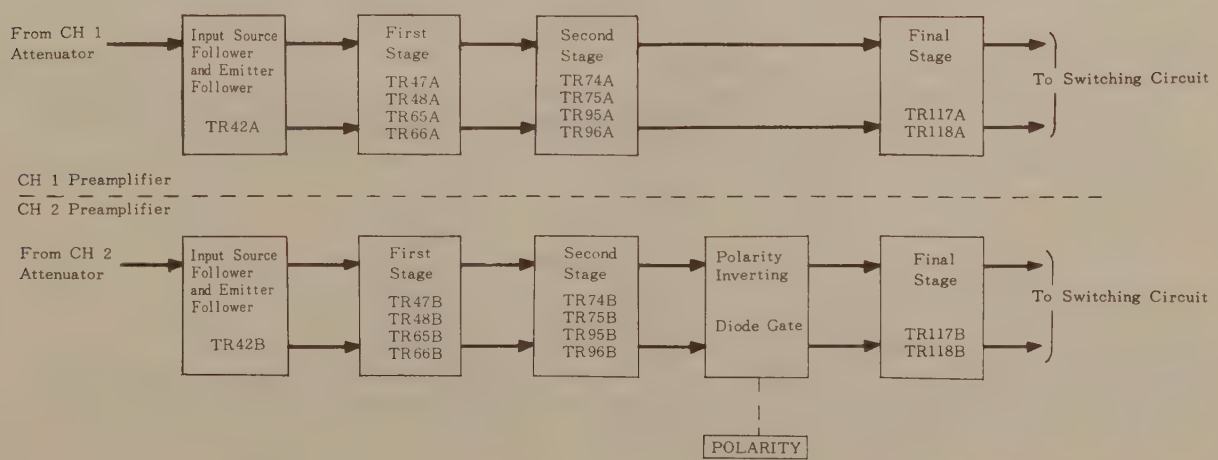
Vertical Input and Attenuator

Input signals connected to the INPUT connector can be AC-coupled, DC-coupled or internally disconnected. When the AC-GND-DC switch is in the AC position, the input signal passes through capacitor C28 to the input attenuator. This capacitor prevents the DC component of the signal from passing to the amplifier. In the DC position, the input signal is coupled directly to the input attenuator. The GND position opens the signal path and connects the input circuit of the amplifier to ground. This provides a ground reference without the need to disconnect the signal applied from the INPUT connector.

Circuit elements R5, and C20 are used to eliminate the ringing from square-wave characteristics.

The attenuator attenuates the input signal to switch the vertical deflection sensitivity in ten different ranges. The 5 mV and 10 mV ranges switch the emitter resistance of the second stage (TR74A/B and TR75A/B) of the preamplifier which is described later. Other ranges 20 mV and above constitute parallel capacitor-compensated resistance dividers.

Figure 4–2 Block Diagram of CH 1 and CH 2 Preamplifier



▷ CH 1 Preamplifier

The circuit configuration of the CH 1 preamplifier is shown in Figure 4–2. The function of this preamplifier is to amplify the input signal from the attenuator and feed it to the switching circuit.

The input source follower TR42A which utilizes a junction FET (field-effect transistor) is equivalent to a vacuum tube cathode follower. This input source follower has a high input impedance and reduces adverse effect on the circuit to be measured. It provides low output impedance to drive the succeeding amplifier stage.

Diode D36A provides protection of TR42A from excessive voltage. For positive excessive input signal, the gate and source of TR42A function as a diode (polarity, as indicated by an arrow mark), permitting current to flow from gate to source. Thus, voltage drop across R37A provides input signal attenuation. For negative excessive input signal, the gate and source of TR42A are reverse-biased, allowing D36A to become conductive. This causes the input signal to be attenuated.

To reduce the temperature drift, twin transistors are used for TR42A. One transistor of the TR42A twins is used to balance the first stage of the preamplifier.

TR47A through TR66A of the first stage form a balanced cascade amplifier provided with the phase inverting function; the input signal is phase-inverted at TR47A and TR48A for the balance signal. The amplified output signal is thus obtained at the collectors of TR65A and TR66A. This amplifier comprises a bridge circuit (R53A, R54A, D53A and D54A) connected to the collector of TR47A, TR48A and the parallel circuit (R61A, C61A and R62A, C62A). These circuits prevent high-frequency damping which would otherwise result from gain decrease of the preamplifier. In other words, when the gain is increased by controlling the VARIABLE control, the output impedance of the circuit on the left as viewed from the bridge circuit is very high and the parallel circuit impedance (R61A, C61A and R62A, C62A) does not affect the signal current flowing into TR65A and TR66A. When the gain is decreased, the output impedance of the circuit on the left as viewed from the bridge circuit is low, and the parallel circuit impedance affects the signal current flowing into TR65A and TR66A, causing C61A and C62A to pass more high-frequency signal components.

The succeeding second stage contains two grounded-emitter balanced amplifiers, in which the balanced signal from the first stage is further amplified. A part of the output signal from the collectors of grounded base amplifiers TR87A · TR89A is fed to the trigger amplifier as the trigger signal for CH 1.

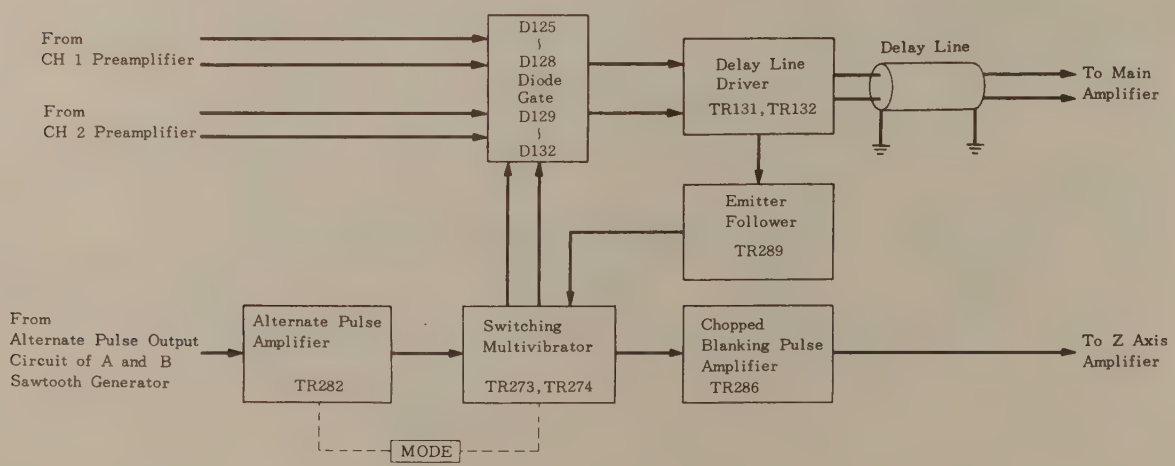
The third stage forms a composite amplifier together with the delay line driver across the diode gate circuit which is covered later. Refer to the paragraph "Switching Circuit," for the composite amplifier.

▷ CH 2 Preamplifier

The circuit configuration of the CH 2 preamplifier shown in Figure 4–2, is identical to that of the CH 1 preamplifier except that the former contains a diode gate circuit.

In the diode gate circuit, the polarity of the display is switched to obtain the sum or difference of two input signals connected to CH 1 and CH 2 INPUT connectors. When the CH 2 POLARITY switch is set to the NORM position, diodes D103B, D107B and D104B, D108B turn off and D102B, D106B and D105B, D109B turn on, and the output of TR95B is fed to the base of TR117B, and that of TR96B is fed to the base of TR118B. When the CH 2 POLARITY switch is set to the INV position diodes D102B, D106B and D105B, D109B turn off and D103B, D107B and D104B, D108B turn on. Accordingly, the output of TR95B is fed to the base of TR118B and that of TR96B is fed to the base of TR117B.

Figure 4–3 Block Diagram of Switching Circuit



▷ Switching Circuit

The switching circuit configuration is shown in Figure 4–3. This circuit opens or closes the diode gate according to the MODE switch setting, thereby switching the connection of the CH 1 or CH 2 preamplifier to feed the balanced signal to the main amplifier.

CH 1

When the MODE switch is in the CH 1 position, a positive voltage of 15 V is applied to the anodes of D130 and D131 through R268, and the potential at the junction of resistors R265 and R271 is applied to the anodes of D126 and D127. (See Figure 4–4.) Accordingly, forward bias is applied to diodes D130 and D131, causing the cathode potential to rise and D129 and D132 to turn off. On the other hand, reverse bias is applied to diodes D126 and D127, causing D125 and D128 to turn on. Consequently, the balanced signal of CH 1 only is fed to the delay line driver.

CH 2

When the MODE switch is in the CH 2 position, a positive voltage of 15 V is applied to the anodes of D126 and D127 through R267, and the potential at the junction of R266 and R272 is applied to the anodes of D130 and D131. Thus, the balanced signal of CH 2 only is fed to the delay line driver.

ALT

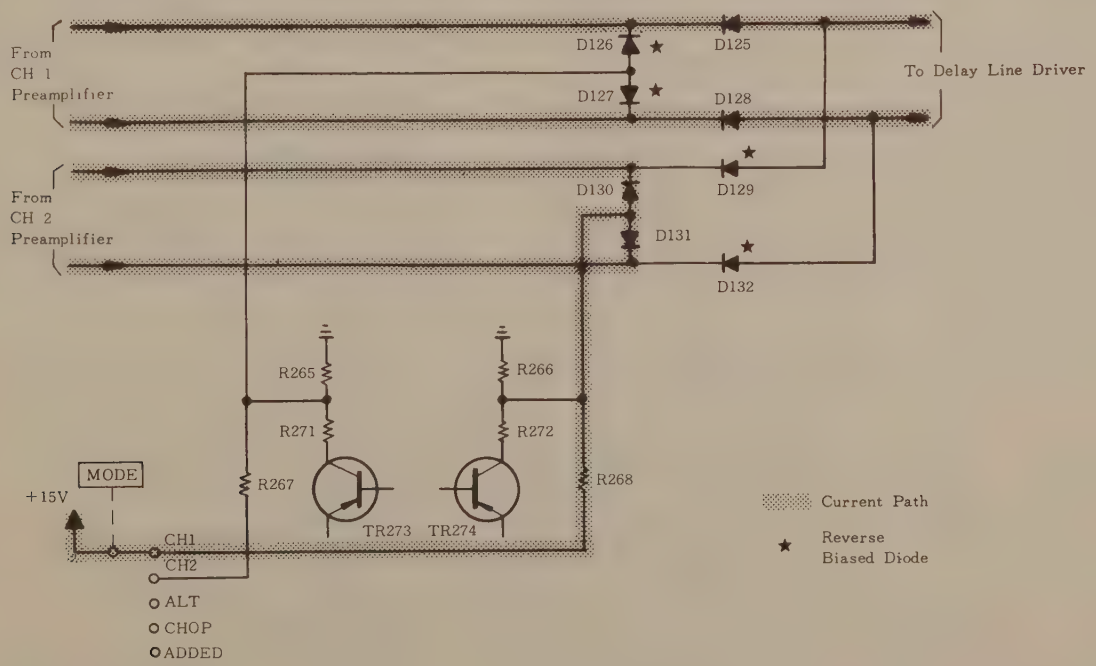
In the ALT mode, a positive voltage of 15 V is applied to the emitter of TR282 of the alternate pulse amplifier. The switching multivibrator functions as a bistable multivibrator. Then, TR282 is turned on, allowing current to flow into the switching multivibrator via D279 or D280.

Assume that TR274 is on, current flows through D280 and TR274. Thus, the potential of the TR274 collector rises, causing the D130 and D131 to turn on and D129 and D132 off. While transistor TR273 remains off with low collector potential, causing D126 and D127 to turn off and D125 and D128 on. Consequently, the balanced signal of CH 1 only is fed to the delay line driver.

At this moment, the negative alternate signal is fed to the base of TR282 through C283. At the end of the sweep, the alternate signal changes to positive. The transition of this pulse is differentiated by C283 and the internal resistance of TR282, and this differentiated positive pulse blocks the current from TR282 and instantaneously turns TR282 off. During the time TR282 is conducting, the TR273 side of capacitor C281 is charged to positive, and the TR274 side is negative. This charge is retained while TR282 is cut off and determines which side of the multivibrator is to conduct next.

When current again starts to flow through TR282, the charge on C281 places the TR273 emitter more positive than that of TR274, and TR273 turns on. The operation of the diode gate is reversed as long as TR278 is on, and the balanced signal of CH 2 only is fed to the delay line driver. In this way, the input signals which are connected to CH 1 and CH 2 INPUT connectors are displayed alternately on the CRT.

Figure 4–4 Switching of Diode Gate (For CH 1)



TR289 is an emitter follower which provides feedback from the delay line driver to drive the diode gate circuit with the minimum switching signal level. The emitter of TR289 is connected to the cathodes of diodes D273 and D274, and functions to minimize the switching signal of the diode gate.

CHOP

In the CHOP mode, the emitters of TR273 and TR274 are connected through R279 (or R280) and the primary of T280 to + 15 V to allow the switching multivibrator to operate as an astable multivibrator (frequency approximately 1 MHz).

Assuming TR274 is conducting, as in the case of ALT mode D130 and D131 turn on and D129 and D132 off, moreover D126 and D127 off and D125 and D128 on, and therefore the balanced signal of CH 1 only is fed to the delay line driver.

The frequency is determined by C281, R279 and R280. Operation of the multivibrator is as follows. When TR274 is conducting, C281 starts to charge toward +15 V through R279, and the emitter of TR273 thus approaches this positive potential (+15 V). The base potential of TR273, at this time, is determined by a voltage divider consisting of R274 and R275, which is between the collector of TR274 and the +15 V line. Therefore, when the emitter potential of TR273 becomes higher, even slightly, than the base potential, TR273 conducts, causing its collector potential to become positive. The other voltage divider consisting of R273 and R276 drives the base potential of TR274 positive to cut off TR276. Next, capacitor C281 starts to charge toward +15 V — through R280 — until TR273 conducts, and TR274 shuts off. The switching of these transistors is then repeated.

Diodes D279 and D280 are reverse biased through D282 and R282 to provide effective switching for the multivibrator (only in the CHOP mode). The emitter follower (TR289) provides switching, as in the case of ALT mode, of the diode gate with the minimum switching signal level.

The chop blanking pulse amplifier, TR286, feeds pulses to the Z axis amplifier to blank the display of transients which occur during the CH 1 and CH 2 switching time. The switching transient of the multivibrator is instantaneously stepped up (amplified) by transformer T280 and the negative output pulse ——— R285 and C285 determine the pulse width ——— is fed to the base of TR286. TR286 clips this pulse, and its output ——— synchronized with the switching transient of CH 1 and CH 2 ——— is fed to the Z axis amplifier.

ADDED

In the ADDED mode, both TR273 and TR274 are cut off, and diodes D126, D127, D130 and D131 also turn off. Simultaneously, diodes D125, D128, D129 and D132 conduct. Therefore, both the CH 1 and CH 2 outputs are fed to the delay line driver. In the ADDED mode, since double amount of current must blow through the diode gate circuit, the MODE switch prevents this current from flowing through resistors R127 and R128.

The delay line driver forms a composite amplifier with the third stages of CH 1 and CH 2 preamplifiers. Resistors R129 and R130 are used as a feedback loop to reduce the impedance of the composite amplifier in order to drive the low impedance delay line and prevent deterioration of frequency response at high frequencies.

▷ Vertical Main Amplifier

The circuit configuration of the vertical main amplifier is shown in Figure 4–5. The balanced signal from the delay line driver is amplified to a level sufficient to deflect the electron beam of the CRT.

Delay Line

To enable the display of the leading edge of an input signal from the internal trigger source, the delay line delays the balanced signal from the delay line driver approximately 80 nanoseconds.

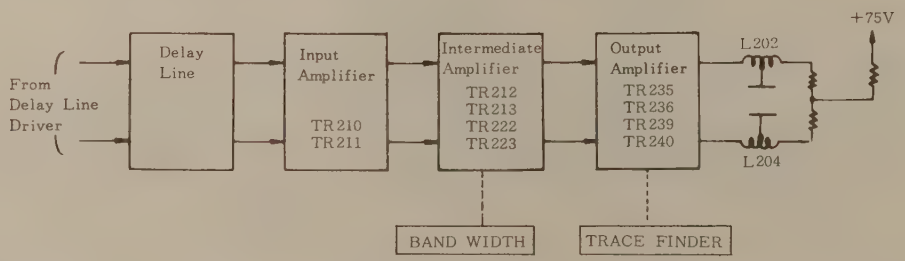
Input Amplifier

The input amplifier consists of TR210 and TR211 which constitute an emitter coupled, balanced type amplifier whose input impedance is comparatively high. Impedance matching with the delay line is effected by R201, R202, and L201 on the base side. The function of this amplifier is to amplify the balanced signal from the delay line.

Intermediate Amplifier

The signal fed from the input amplifier is applied to the emitters of TR212 and TR213 composing a grounded base amplifier, to obtain a balanced output signal. This amplifier (TR212 and TR213) is connected with a circuit composed of C220, C221 and D220 at its output side.

Figure 4–5 Block Diagram of Vertical Main Amplifier



When the BANK WIDTH switch is set to the FULL range, D220 is reverse-biased, which has no effect on C220 is reverse-biased, which has no effect on C220 and C221.

When switched to the 50 MHz range, D220 is forward-biased, reducing the frequency bandwidth to 50 MHz through C220 and C221.

Output Amplifier

The output amplifier consists of an emitter follower formed by TR235 and TR236 and an emitter coupled, balanced type amplifier consisting of TR239 and TR240.

The functions of the emitter follower are to convert the impedance, to drive the balanced type amplifier, and to provide current amplification.

The balanced amplifier amplifies the balanced signal to a level sufficient to deflect the electron beam of the CRT. L202 and L204 are the circuit elements which constitute the delay line with the stray capacity between the deflection plates in order to delay the balanced signal applied to the plates in accordance with the beam delay within the CRT. The load of the balanced amplifier consists resistors R251 through R258, and the function of R256 is to effect impedance matching with the delay line.

The TRACE FINDER is a pushbutton switch which decrease the amplification factor of the balanced amplifier to aid in locating the position of the trace on the CRT.

▷ Trigger Amplifier

The trigger amplifier employs the circuit configuration shown in Figure 4–6. This amplifier amplifies the balanced trigger signal output from the CH 1, or CH 2 preamplifier, and feeds it to the trigger generator. This amplifier also boosts the CH 2 input signal by 5 times, and supplies it to the CH 2 OUT connector.

CH 1 Amplifier

The emitter follower consisting of TR144A provides a high input and a low output impedance for this circuit. The input trigger signal is fed through the emitter follower, to the two-stage amplifier comprised of TR150A, TR151A, TR161A. and TR162A. Transistors TR173A and TR174A together with the diode gate and the negative feedback amplifier form a composite amplifier.

CH 2 Amplifier

Configuration of the CH 2 amplifier is identical to the CH 1 amplifier.

Diode Gate

Depending on the mode selected by the MODE and TRIGGER switch, the diode gate connects the CH 1, or CH 2 trigger signal to the negative feedback amplifier. In other words, when the MODE switch is in the CH 1 position, the cathodes of diodes D175B and D176B are grounded to allow these diodes to conduct, and diodes D177B and D178B are cut off. Diodes D175A and D176A are shut off and D177A and D178A conduct in this mode. Therefore, only the CH 1 trigger output is fed to the negative feedback amplifier (except when the HORIZ DISPLAY switch is set in the EXT HORIZ position). When the MODE switch is set in the CH 2 position, the aforesaid diode operation is reversed, and the CH 2 trigger signal is fed to the negative feedback amplifier. In ALT, CHOP or ADDED positions of the MODE switch, the diode gate is switched by the channel assigned by the TRIGGER switch.

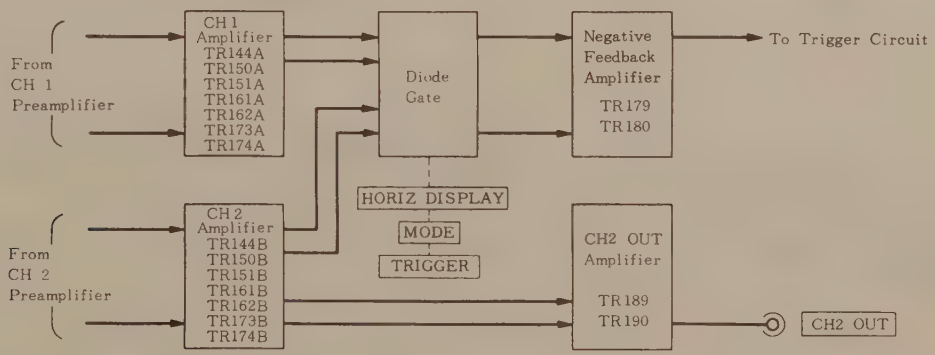
Negative Feedback Amplifier

The negative feedback amplifier, together with the trigger preamplifier output transistors, TR175A, TR176A, or TR175B, TR176B which are selected by the diode gate, composes a composite amplifier. The preamplifier output is amplified by the composite amplifier and fed to the trigger generator.

CH 2 Out Amplifier

The external signal fed to the CH 2 INPUT is taken from the collector of TR189B and TR190B (in the CH 2 amplifier) and fed to the CH 2 OUT amplifier from which it is supplied to the CH 2 OUT connector.

Figure 4–6 Block Diagram of Trigger Amplifier



▷ A Trigger Generator

The circuit configuration of the A TRIGGER GENERATOR is shown in Figure 4–7. The generator produces a pulse output to trigger the A sweep generator. This trigger pulse is synchronized with the signal branched from the vertical deflection system (INT trigger), the external trigger signal supplied to the TRIG INPUT, or the line trigger signal supplied from the power transformer.

Trigger Signal Selection

The SOURCE switch selects the source of the trigger signal from the internal (vertical) signal, the external signal, or the line frequency signal. The EXT÷10 position is used to attenuate the external trigger signal by 10:1.

The internal trigger signal is obtained through the aforesaid trigger amplifier from the vertical input signal. As described in the previous section, "Trigger Amplifier," the internal trigger signal is selected by the TRIGGER switch from the CH 1 or CH 2 signal.

For line trigger, the 6.3 Vrms from terminals 15 and 16 of power transformer T1000 is reduced to approximately 1.5 Vrms by the voltage divider consisting of R1075 and R1068, and then fed through pin 17 of P700. If the COUPLING switch is set to the LF REJ position, the line signal is attenuated, and line triggering is impossible.

The external trigger signal supplied to the TRIG INPUT connector is fed to the trigger generator when the SOURCE switch is in the EXT or the EXT÷10 position. The attenuator in the EXT÷10 position reduces the external trigger signal by 10:1. This switch position is used when the external trigger signal is excessively large.

Trigger Signal Input Coupling Selection

The COUPLING switch selects the coupling mode between the trigger signal and the input source follower. In the AC position, capacitor C304 is inserted in series with the input circuit to block the DC component of the input signal while allowing AC signals higher than approximately 30 Hz to pass. In the LF REJ position, a high-pass filter composed of C304 and R305 decouples low frequency noise superimposed on the trigger signal, and low frequency components (lower than approximately 30 kHz) of the trigger signal. The low-pass filter in the HF REJ position is composed of R304 and the stray capacitance of the circuit. This filter attenuates high-frequency components and noise (higher than approximately 50 kHz) in the trigger signal and allows only low-frequency trigger signals (from approximately 30 Hz to 50 kHz) to pass. In the DC position all input signals are coupled directly to the input source follower.

Input Source Follower and Emitter Follower

An FET is used for the input source follower which provides a high input impedance and a low output impedance.

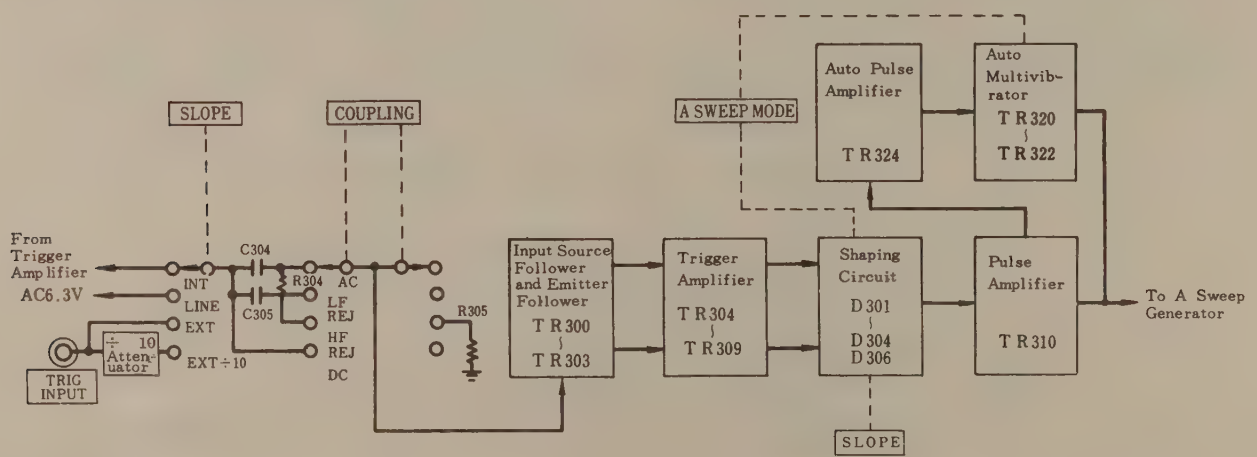
The source follower output is fed to the emitter follower which reduces the output impedance sufficiently to drive the succeeding trigger amplifier.

The functions of TR301 and TR303 are to provide DC balance in the trigger amplifier and to effect impedance matching. The LEVEL control is used to determine the level on the amplitude of the triggering waveform at which the sweep will start.

Trigger Amplifier

The TR304 and TR305 constitute a phase inverter which converts the trigger signal from the emitter follower composed of TR302 into balanced signals, and amplifies them. These signals are further amplified by the succeeding second stage of the amplifier and fed to the shaping circuit.

Figure 4–7 Block Diagram of A Trigger Generator



Shaping Circuit and Pulse Amplifier

The shaping circuit consists of a diode gate formed by diodes D301 through D304 and a tunnel diode D306 which is used to convert the trigger signal into a square wave. This diode gate is opened or closed as determined by the position of the SLOPE switch, and feeds the signals, 180° out of phase, from TR308 and TR309 to diode D306. The action of D306 differs with the positions of the A SWEEP MODE switch. In other words, this switch changes the impedance which is in parallel with D306, thereby varying the slope of the load line with regard to the characteristic curve of D306 to switch D306 from an astable to a bistable multivibrator or vice versa. It is a bistable multivibrator at a position other than HF and at this position it will become an astable multivibrator.

At positions other than HF A case in which the SLOPE switch is set at the + position is used as example. Since a voltage of approximately −11 volts (due to zener diode D305) is applied to the cathode side of D303, as shown in Figure 4–8, D303 turns on and D301 turns off. During this time, D304 turns off and D302 turns on. Therefore, current flows as indicated in Figure 4–8, causing the trigger signal from TR309 to be fed to D306.

Resistor R339 and inductor L300 are connected in parallel with D306 and its load line will become as shown in Figure 4–9. The sine wave (trigger signal) shown in the same figure is applied to the diode with this load line as the reference, and if the LEVEL control is adjusted for the trigger level indicated by the broken line, current i_1 flows through D306 at time 0 and the operating point on the

Figure 4–8 Current Flow in Shaping Circuit (when the SLOPE switch is set at the +position)

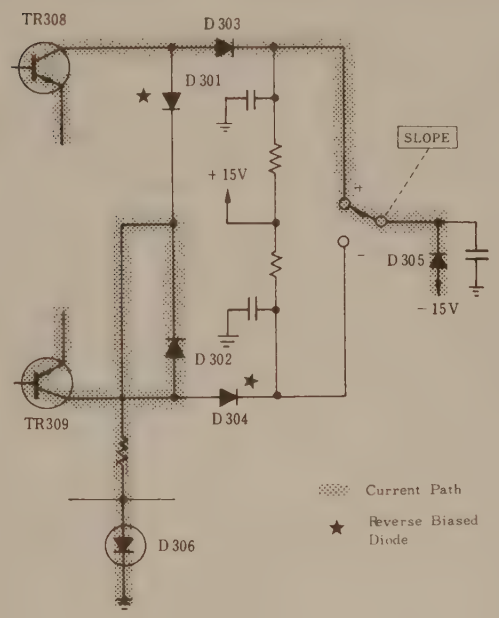
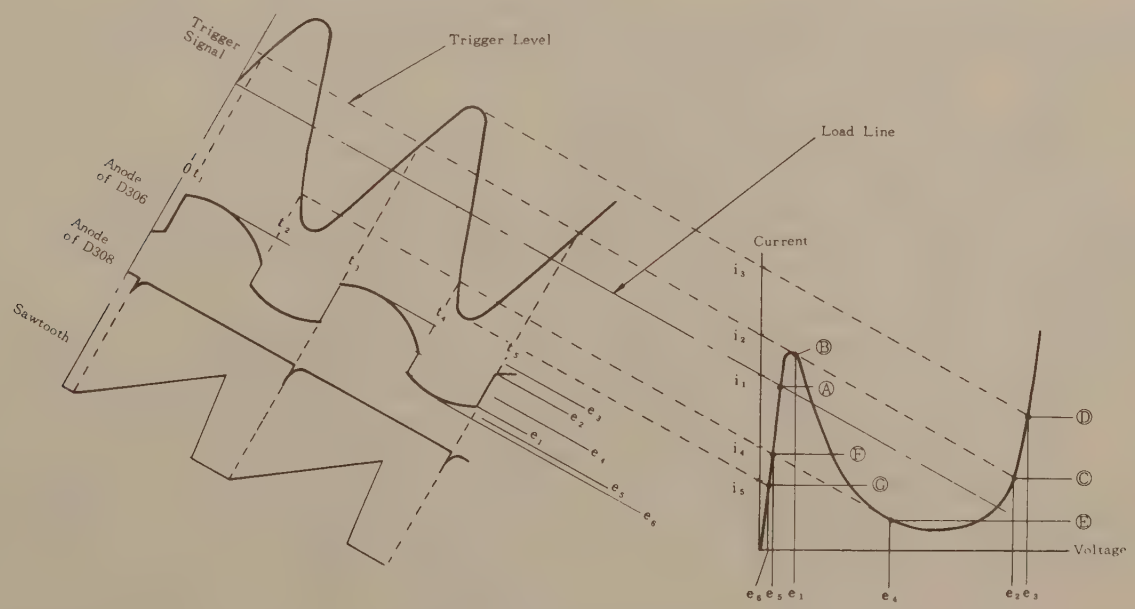


Figure 4–9 Operation of Tunnel Diode (when the SLOPE switch is set at the +position)



characteristic curve of D306 lies on point A. When the sine wave amplitude exceeds the trigger level i_2 at time t_1, D306 rapidly steps to point C. When the maximum value of sine wave is reached and current i_3 flows, the operation point shifts to point D. Subsequently, when the sine wave amplitude decreases and current decreases to level i_4 at time t_2, D306 rapidly steps to point F. As the sine wave amplitude further decreases, the operating point moves to point G, then when the sine wave reaches the point corresponding to time t_3, D306 again steps on to point C; in this way, D306 is triggered by the trigger signal.

With D306 triggered as explained above a square wave (shown in Figure 4–9) is generated on the anode side of D306, and is fed to the pulse amplifier TR310. When this square wave becomes positive, current immediately flows through TR310, and a negative pulse differentiated by pulse transformer T300 and capacitor C318 appears on the collector of TR310. The positive pulse which is produced when the square wave becomes negative is absorbed by D307. Consequently, this negative pulse is fed to D308 for use as a trigger pulse for the sweep generator in the succeeding stage.

As shown in Figure 4–9, trigger pulses are produced at t_1, t_3, t_5 ....., and if the trigger level is varied by changing the position of the LEVEL control, it is possible to generate a trigger pulse at an arbitrary point on the + slope of the trigger signal (sine wave). (See Figure 4–9) This signifies that sawtooth waves for sweeps are generated by these trigger pulses, and since the amplified input signals applied to the vertical deflection plates of the CRT and the

Figure 4–10 Current Flow Shaping Circuit (when the SLOPE switch is set at the –position)

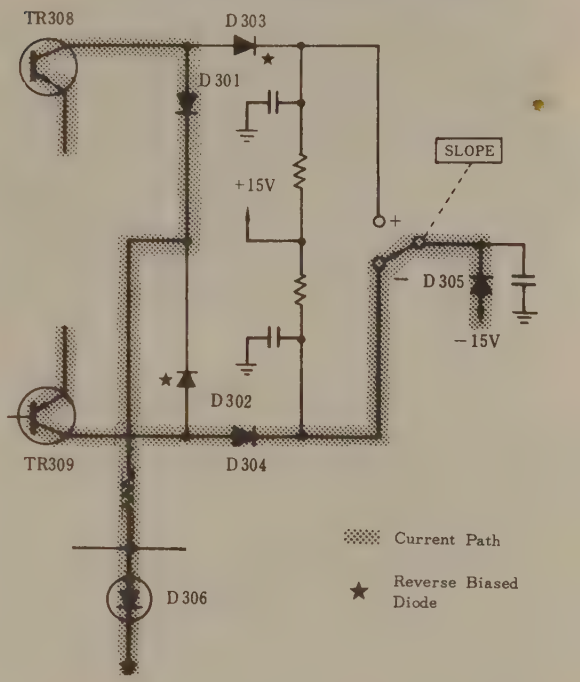
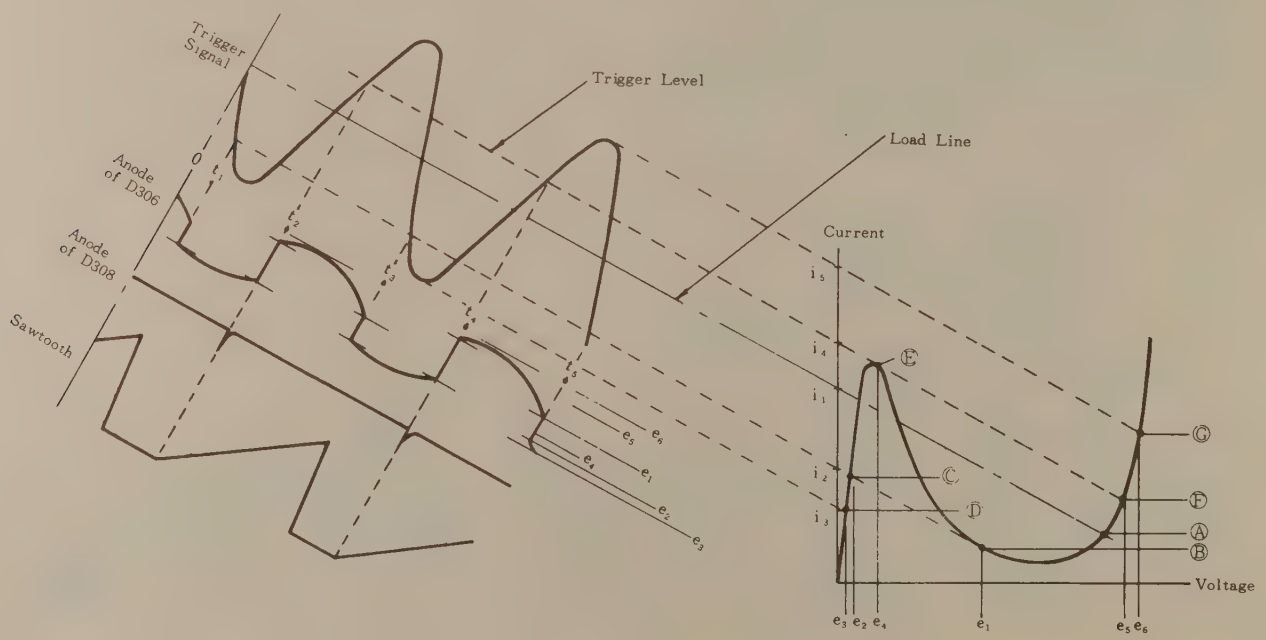


Figure 4–11 Operation of Tunnel Diode (when the SLOPE switch is set at the –position)



trigger signals supplied to D306 are of the same phase, the sweep can be triggered at a selected point on the + slope of the input signal.

When the SLOPE switch is set at the – position, the direction of the current which flows through the diode gate is opposite to that shown in Figure 4–10 (when the SLOPE switch is set at the + position), and the trigger signal from TR308 is fed to D306. The phase of this trigger signal is inverted from that of the trigger signal from TR309. This is shown in Figure 4–11.

Now, suppose the trigger level set by the LEVEL control is as shown in this figure; current i_1 flows through D306 at time to, and the operation point moves to point A on the characteristic curve of D306, and then, as in the case in which the SLOPE switch is set at the + position, D306 is triggered by the trigger signal. However, the trigger pulses generated at time t_2, t_4 ....., are 180° out of phase as compared to those in the + position. Since the trigger signal which is applied to D306 is 180° out of phase from the input signal, the sweep can be triggered at an optional point on the – slope of the input signal.

For HF As the frequency of the trigger signal becomes higher, the triggering of D306 becomes more difficult. To overcome this difficulty, in this position (HF) D306 is made to assume a free-run state to effect a forced synchronization by the trigger signal. With this method D306 is easily triggered with a considerably higher frequency trigger signal. In the HF mode, D306 is in this free-run state.

When the A SWEEP MODE switch is set at the HF position, R344 and L301 are connected in parallel with D306, thereby causing the slope of the D306 load line to become steep. If, at this time, the D306 current is varied by the LEVEL control to move the load line into the negative resistance region of the D306 characteristic curve, D306 will oscillate as an astable multivibrator. If the level is changed by the LEVEL control, after applying the trigger signal, it is possible to synchronize a comparatively high frequency input signal, since the oscillation frequency is synchronized with the trigger signal frequency.

Auto Pulse Amplifier and Auto Multivibrator

When the A SWEEP MODE switch is set at the AUTO position, the A sweep generator assumes a triggered state or free-run state depending on the presence or absence of trigger pulses.

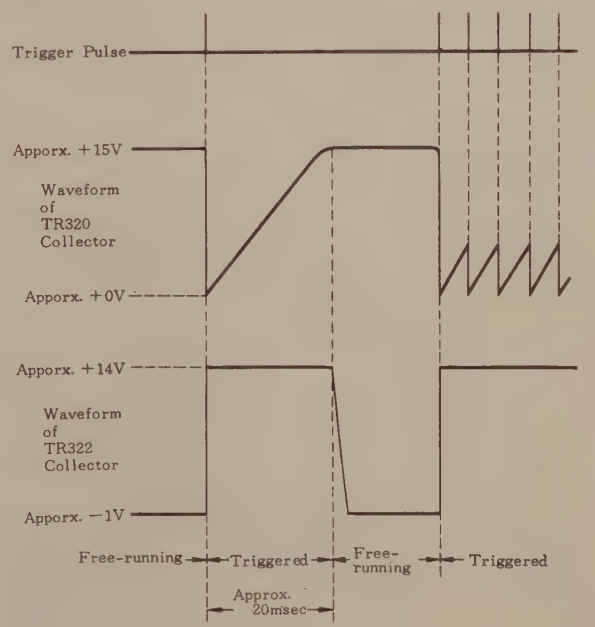
When trigger pulses are absent The auto pulse amplifier TR324 is not associated with the operation in this mode. The operation of the auto multivibrator is as follows:

Since current flows through T302 and R305 to D310, the base potential of TR320 is clamped at approximately –0.7 volts, and the base voltage of TR321 is divided by R352 and R353 to approximately –0.3 volts. Consequently, TR321 turns on and TR320 turns off. C320 is charged through R351 causing D312 and D313 to be turned on. Current flows through these diodes from the +75 volts through R351, TR321 and R354. TR322 turns off since reverse bias is applied between the emitter and base. D314 also turns off, therefore current flows through R359 to D315. This current moves the operation point of the gate multivibrator, D400, in the A sweep generator from point A to point B in Figure 4–14. As stated in the paragraph entitled, "A Sweep Generator," this generator oscillates on a free-run basis when the operation point of D400 is in point B.

When trigger pulses are present The moment the trigger pulse are fed from T300 of the pulse amplifier to the A sweep generator, the emitter of TR310 produces a pulse whose polarity is opposite to that of the trigger pulse. The pulse is amplified by TR324. The polarity of this pulse is inverted by T302 and fed to the base of TR320 as positive pulse. With this pulse TR320 turns on and TR321 turns off, and the collector potential of TR320 steps into the negative region, which causes C320 to rapidly discharge. (See Figure 4–12 for the following discussion.) Consequently, D312 and D313 turn off and TR322 turns on. As a result, the collector potential of TR322 attains approximately +14 volts. This, in turn, causes D314 to turn on and D315 to turn off, and the operating point of D400 shifts to point A in Figure 4–14. The A sweep generator is then triggered.

When the trigger pulse disappears, TR320 turns off and TR321 turns on again. The collector potential of TR320 increases gradually depending on the time constant of R351 and C320, and when approximately +15 volts is reached, D312 and D313 turn on, and TR322 turns off, causing its collector potential to step into the negative region (approximately –1 volt). As shown in Figure 4–12, if trigger pulses are continuously applied before the TR320 collector potential increases (until D312 and D313 turn on), TR322 will not be able to turn off, and the triggered state of the A sweep generator is maintained. However, if the trigger pulse internal becomes longer than approximately 20 msec

Figure 4–12 Auto Multivibrator Waveform



(approximately 50 Hz), the triggered state of the A sweep generator can no longer be maintained since the TR322 collector potential steps into the negative region.

▷ A Sweep Generator

The configuration of the A sweep generator is shown in Figure 4–13. When the HORIZ DISPLAY switch is set to a position other than EXT HORIZ, three operation modes, normal trigger, automatic operation or single sweep are available.

The A sweep generator provides the following five types of signals.

(1) Sawtooth Wave — The sawtooth wave is fed through the horizontal preamplifier to the horizontal diflection plates of the CRT. The signal is also fed to the B sweep generator in order to produce the delay pulse.

(2) Unblanking signal to intensify trace and blank retrace — Fed to the unblanking amplifier and the control grid of the CRT.

(3) Positive gate pulse provided during the positive going slope of the sweep waveform — Fed to the A GATE output connector located on the right side panel.

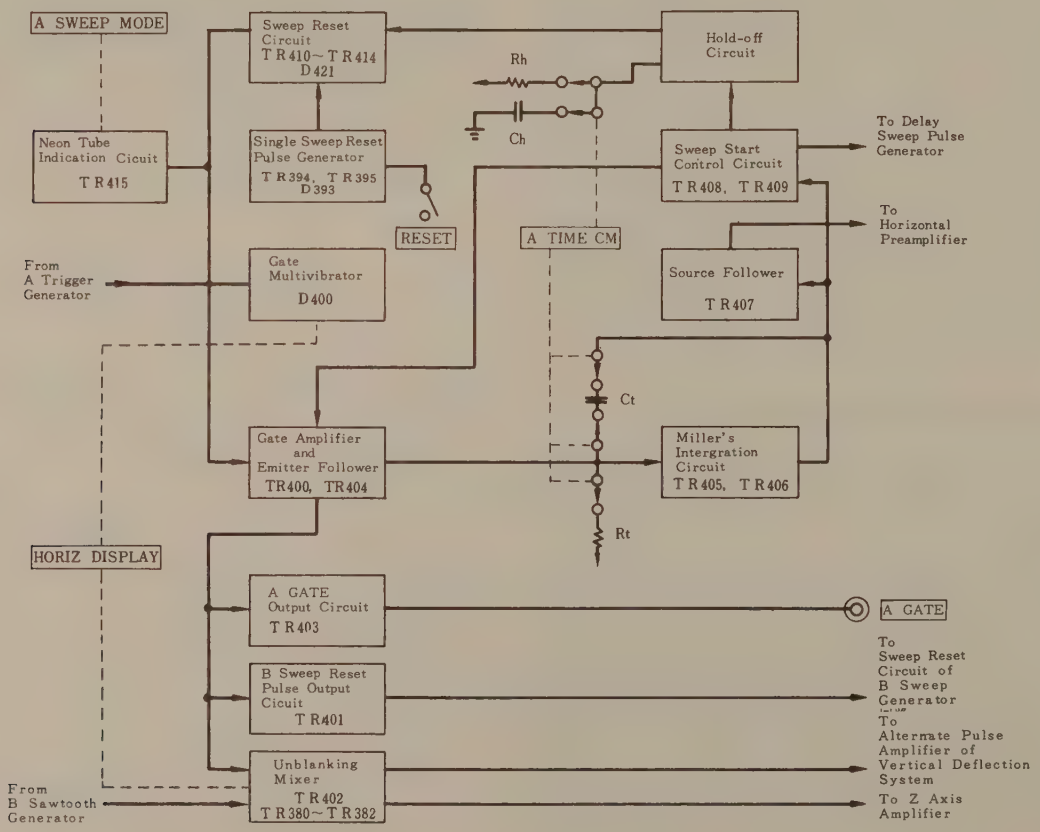
(4) Reset pulse to deactivate the unnecessary part of the B sweep signal during the A INTEN BY B sweep operation — Fed to the B sweep generator.

(5) Alternate signal to actuate the alternate sweep — Fed to the alternate pulse amplifier in the vertical deflection system.

Normal Trigger Operation (Basic Operation)

Normal trigger operation of A sweep generator is performed by setting the HORIZONTAL DISPLAY switch to any position other than EXT HORIZ and the A SWEEP MODE switch to the NORM position. Strictly speaking these normal triggered operations differ to some extent with the HORIZ DISPLAY switch position. For ease of description, operation in which the HORIZ DISPLAY switch is set to the A position will be used as an example.

Figure 4–13 Block Diagram of A Sweep Generator


A SWEEP MODE
Sweep Reset Circuit TR410~TR414 D421
Hold-off Circuit
Rh
Ch
Neon Tube Indication Cicuit TR415
Single Sweep Reset Pulse Generator TR394, TR395 D393
Sweep Start Control Circuit TR408, TR409
To Delay Sweep Pulse Generator
To Horizontal Preamplifier
RESET
A TIME CM
From A Trigger Generator
Gate Multivibrator D400
Source Follower TR407
Ct
Gate Amplifier and Emitter Follower TR400, TR404
Miller's Intergration Circuit TR405, TR406
Rt
HORIZ DISPLAY
A GATE Output Circuit TR403
A GATE
To Sweep Reset Circuit of B Sweep Generator
B Sweep Reset Pulse Output Cicuit TR401
To Alternate Pulse Amplifier of Vertical Deflection System
Unblanking Mixer TR402 TR380~TR382
From B Sawtooth Generator
To Z Axis Amplifier

Assume a condition before the sweep starts with no trigger signal. TR413 in the sweep reset circuit is conducting and D315 of A trigger generator is off, and a very small amount of current flows through gate multivibrator D400 (a tunnel diode) to place the operating point of the diode in the low voltage region, C. (Figure 4–14) The cathode potential of the diode is approximately –0.04 V (see Figure 4–15), and is higher than when the diode is in the high-voltage region. (The anode of D400 is grounded, therefore, the high-voltage operation of the diode means that the cathode is placed at a more negative potential.)

The gate amplifier, TR401, is shut off in this condition, and its collector potential is approximately –4 V. Diode D403 is connected to the emitter of TR404, and current flows through the diode through Rt.

An amplifier composed of TR405 and TR406 is connected to the anode of D403. Ct forms a feedback circuit between the output and input of the amplifier and constitutes a Miller integrator circuit. The output of the integrator circuit is fed to the horizontal preamplifier and the base of TR408. TR408 and TR409 compose a voltage comparator (sweep start control circuit) from which the output is returned, through diode D415, to the base of TR404. Diode D415 conducts before the sweep start, therefore, a DC feedback loop is formed by TR405 → TR406 → TR408 → TR415 → TR404 → TR405. Rt and Ct determine the time constant of the Miller integrator circuit. The time constant varies with the position of the A TIME/CM switch. Switching of Rt causes a variation in the input and output potential of the amplifier composed of TR405 and TR406, however due to the feedback loop, the output potential is maintained approximately constant.

The cathode of diode D417 is connected to the emitter of TR408, and current flows from the diode through Rh. The anode of the diode is connected to the gate of TR410.

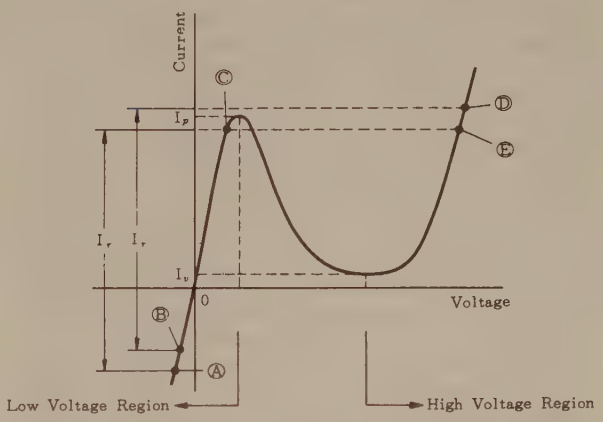
A tunnel diode, D421, is connected to the collector of TR412. Before the sweep starts, the gate potential of TR410 is sufficiently higher than the base potential of TR412, therefore, TR410 shuts off, TR412 conducts, and D421 is set in the high voltage region. The comparator output is connected to the base of TR413. Diode D421 is in the high voltage region at this time, and TR413 is conducting. The collector voltage of TR413 is approximately zero, and a very small amount of current flows through R455.

If a trigger pulse is fed from the A trigger generator to the cathode of D400, the diode current exceeds Ip, the tunnel diode steps to the high voltage region, (point E in Figure 4–14) and the cathode potential becomes approximately –0.5 V (refer to Figure 4–15).

The collector of TR400 becomes more positive, D403 and D415 are shut off, and the Miller integrator circuit, composed of TR405 and TR406, starts the integration operation with the time constant determined by Rt and Ct. The gate potential of TR405 starts to increase linearly (since capacitor Ct charges through Rt), and then, collector voltage of TR406 also decreases linearly. This voltage variation shuts TR409 off, and the emitter potential of TR408, which operates as an emitter follower, also starts to decrease.

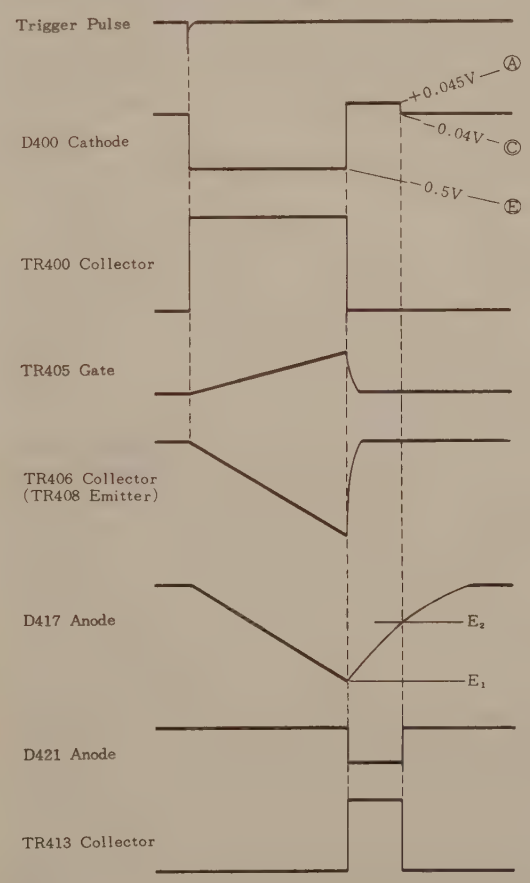
Since D417 is on, its anode potential also decreases linearly. At a certain gate potential (Ei), TR410 turns on, and TR412 turns off, causing tunnel diode D421 to step to the low-voltage region. TR413 then shuts off.

Figure 4–14 Tunnel Diode Characteristics (D400, D600)



Ir represents current in D400, or D600, when TR413 or TR612 is sweep reset circuit conducts.

Figure 4–15 Normal Trigger Operation Waveforms



The potential increase on the collector of TR413 causes current to flow through R455, and the forward current of tunnel diode D400 decreases. D400 steps to its low-voltage region (point A in Figure 4—14), and the cathode potential becomes more positive (approximately +0.045 V — refer to Figure 4—15). Therefore, TR400 shuts off and its collector voltage becomes more negative, causing diodes D403 and D415 to conduct.

The conduction of D403 discharges Ct, and the gate potential of TR405 rapidly decreases while the collector potential of TR406 rises. TR409 is still cut off, and the emitter potential of TR408 rises to approximately equal that of the collector of TR406. The anode potential of D417 increases gradually, due to its capacitive load consisting of Ch. D417 shuts off, and the anode potential increases with a time constant determined by Rh and Ch.

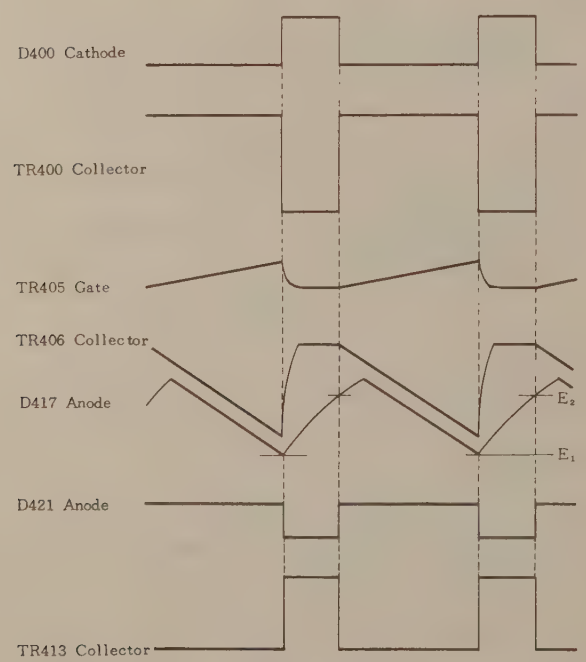
When the anode of D417 reaches a certain potential (E2), TR410 shuts off, and TR412 conducts. D421 steps to the high-voltage region. TR413 conducts, and the forward current of D400 increases to change the operating point of the tunnel diode to point C as its cathode potential steps to —0.04 V (refer to Figure 4—15). The tunnel diode returns to its initial operating point wherein an incoming trigger pulse can drive the diode toward the high voltage region.

At the same time, the rise of TR406 collector potential returns TR408 and TR409 to their normal operating region — a voltage comparator region — and these transistors operate to stabilize the collector potential of TR406.

The time it takes the anode potential of D417 to increase from E1 to E2, or the time during which the anode of D421 is negative, is called the hold-off time. The hold-off time must be sufficiently longer than the time it takes for the collector potential to restore to normal (retrace time). Proper hold-off time is determined by selecting the values of Rh and Ch.

One cycle of normal sweep operation ends when D400 returns to its initial operating status.

Figure 4—16 Auto Operation Waveforms



Auto Operation

By placing the HORIZ DISPLAY switch in any position other than EXT HORIZ and the A SWEEP MODE switch in the AUTO position, the A sweep generator starts auto-triggered sweep. In order to simplify the description, the auto trigger operation will be described with the MODE switch set in the A position.

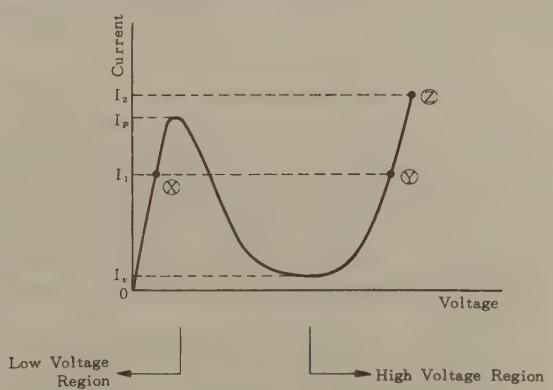
As previously described in the section on the "A Trigger Generator — Auto Pulse Amplifier and Multivibrator," the auto trigger operation is classified into two types, i.e., trigger pulse's presence and trigger pulse's absence. The triggered operation is similar to the normal trigger operation.

When the trigger pulse is not present, the auto multivibrator in the A trigger generator — TR322 — is shut off, and a small amount of current flows through D315 to change the operation point of D400 from point A to point B as shown in Figure 4—14.

When the sweep reset transistor, TR413, conducts in this condition, current similar to that in normal trigger operations flows through R455; the operating point of D400 moves to the high voltage region (point D in Figure 4—14) even if the trigger pulse is not present, and the cathode potential of D400 becomes negative to start the aforesaid sweep operation. When the anode potential of D417 increases to E2 at the end of a sweep (see Figure 4—16), TR413 again conducts to start another sweep. Waveforms for this operation mode are shown in Figure 4—16.

When a negative trigger pulse is fed to D400, D314 conducts and D315 is shut off since the collector of TR322 is at +14 V as described in the section "A Trigger Generator — Auto Pulse Amplifier and Auto Multivibrator." As in normal trigger operation, current flows through D400 to start the sweep. If the pulse interval is longer than approximately 20 msec, TR322 shuts off before the next trigger pulse arrives and the sweep free-runs.

Figure 4—17 Tunnel Diode Characteristics (D421)



Single Sweep Operation

Single sweep operation is possible in any position of the HORIZ DISPLAY switch except the EXT HORIZ position. In this paragraph, single sweep operation in which the HORIZ DISPLAY switch is set to the A position will be described. In the single sweep mode, TR411, TR414 in the sweep reset circuit not related to normal trigger operation, and TR415 in the neon tube indication circuit are actuated.

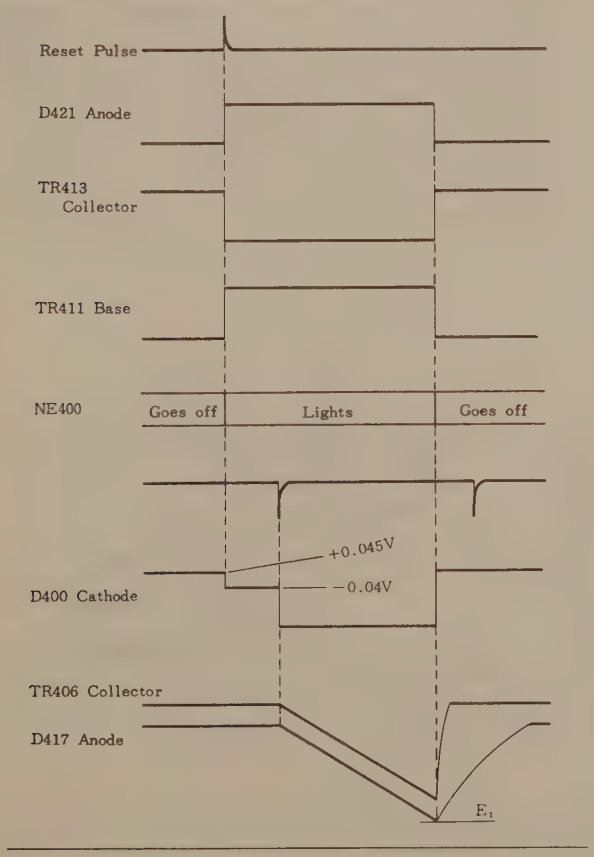
Assume a condition with neither a trigger nor a reset pulse.

The gate multivibrator D400 is in the low-voltage region (point A in Figure 4—14), and the cathode is approximately +0.045 V (refer to Figure 4—18). TR400 is shut off, and its collector is approximately —4 V. D403 and D415 are conducting, TR408 and TR409 are in the voltage comparator region, Ch are charged, and D417 is conducting.

The gate potential of TR410 is sufficiently higher than the bases of TR411 and TR412, and TR410 is shut off. The bases of TR411 and TR412 are at approximately the same potential, and current flowing through R445 (I2 in Figure 4—17) is equally distributed to TR411 and TR412. In other words, the current through TR412 (D421) is I1 in Figure 4—17, and that flowing through TR411 is I2 — I1. Therefore, the operating point of tunnel diode D421 is point X in Figure 4—17. This current shuts off TR413 and keeps a high potential on its collector.

An amplifier, TR414, and neon tube indicated circuit, TR415, are connected to the collector of TR413. The high potential on the collector of TR413 causes TR415 to conduct. Therefore, the potential on the collector of TR415 is low, and the neon tube does not light.

Figure 4—18 Single Sweep Operation Waveforms



Prior to generating a reset pulse, the single sweep reset pulse generator is in the following condition: TR394 is shut off ——— base potential is approximately —3.4 V, and collector potential is approximately +8 V, and tunnel diode D393 is in the high voltage region. TR395 is shut off since its base potential is approximately —0.45 V. Then, the collector potential becomes approximately —15 V.

When a reset pulse is produced by depressing the RESET switch, the base potential of TR394 becomes positive to allow TR394 to conduct. D393 steps to the low-voltage region causing TR395 base to become negative and allowing TR395 to conduct. The positive transition of the collector of TR395 is differentiated by R397 and C398, and a positive pulse (single sweep reset pulse, or simply the reset pulse) is generated and fed to the anode of D421.

The reset pulse drives D421 to its high-voltage region (point Y in Figure 4—17) and its anode potential becomes more positive (refer to Figure 4—18). TR413 conducts causing its collector potential to become more negative. TR414, which is a phase inverter, increases the base potential of TR411 to a point sufficiently higher than that of TR412. TR411 then shuts off and TR412 conducts. The collector current of TR412 increases; the operating point of D421 moves to point Z in Figure 4—17, and the diode operation is stabilized. The decreased collector potential of TR413 increases the forward current of gate multivibrator D400 to move its operating point to point C in Figure 4—14, and the cathode of D400 becomes negative (to —0.04 V, refer to Figure 4—15). At this time, the circuit is in a ready condition and a trigger pulse can drive D400 to its high-voltage region and start the sweep. The decrease in collector voltage of TR413 also decreases the base potential of TR415 which is then shut off. Neon tube NE400 lights to indicate the ready condition of the single sweep circuit.

When a trigger pulse is applied, D400 steps to its high-voltage region (point E in Figure 4—14), its cathode potential is reduced, and the sweep starts. The anode potential of D417 decreases, along with the linear voltage decrease of the collector of TR406, until the anode voltage reaches E1 and TR410 conducts and TR412 is shut off (TR411 has been shut off). D421 steps to its low voltage region (approximately 0 point in Figure 4—17), and its anode potential becomes negative. This negative transition causes the collector of TR413 and the cathode of D400 to become positive. The sweep ends and the potentials on the collector of TR406 and the cathode of D417 start to increase. Simultaneously, TR415 conducts, NE400 goes off, and the base of TR411 becomes more negative and approximately equal to the base potential of TR412.

Because of its capacitive load, the anode potential of D417 can not follow the rapid rise in cathode potential, and the anode potential gradually increases at a time constant determined by Rh and Ch, until it reaches the point indicated by E2 at which time TR410 shuts off (similar to normal trigger operation). The base of TR411 is at the same potential as that of TR412, therefore the current flowing through R445 is equally distributed to these two transistors, and the operating point of D421 is set to point X in Figure 4—17. An incoming trigger pulse can not actuate the sweep unless the anode of D421 is driven by a reset pulse to drive the diode positive.

▷ B Trigger Generator

The configuration of the B trigger circuit is shown in Figure 4–19. The purpose of this circuit is to produce trigger pulses to drive the B sweep generator. The circuit from the TRIG OR HORIZ INPUT connector to the input source follower also functions as an input circuit for horizontal input signals when the instrument is used as an XY oscilloscope. The B trigger circuit consists of a HORIZ DISPLAY switch, which switches the associated circuits from one circuit to another, as mentioned above, and a horizontal signal amplifier. It also contains a DLY'D (B) MODE switch which is used to switch the associated circuits from triggered delay sweep to non-triggered delay sweep, or vice versa. Since the circuit up to the input source follower is identical to that of the A trigger circuit, further discussion is omitted here.

Pulse Shaper and Pulse Amplifier

The pulse shaper circuit is composed of transistors TR502, TR503, TR504 and diode D509. The emitters of TR502 and TR503 are connected to the −15 V line through the common emitter resistor R523 which provides current switching of the transistors (when one transistor turns on, the other shuts off).

For example, when the base potential of TR502 is higher than that of TR503, TR502 conducts and TR503 cuts off. This current switching also switches the operating point of the tunnel diode, and converts the trigger signal into a trigger pulse with a very fast rise time.

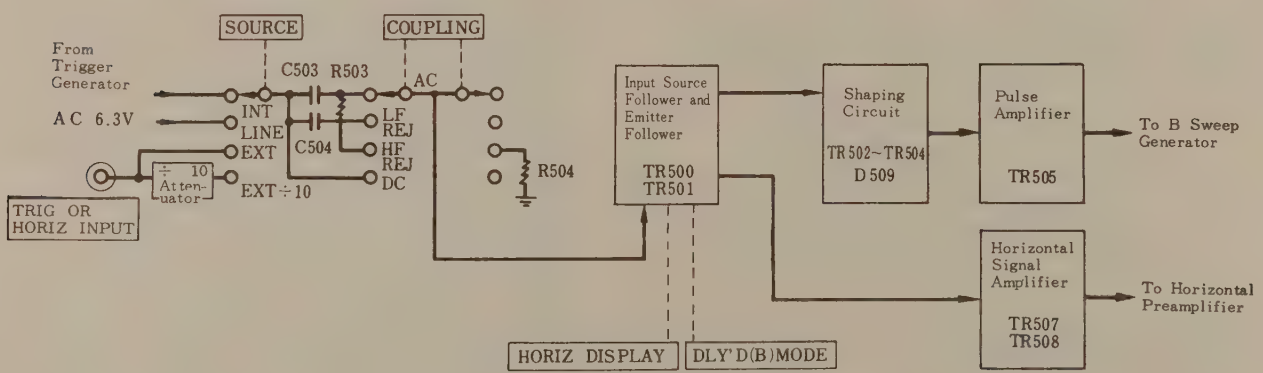
Assuming that the SLOPE switch is set to the + position, + 15 V is connected to the anode of D508 (as shown in Figure 4–20) which then conducts, and D506 turns off. Current flows through D507 as shown in Figure 4–20. When the trigger signal (sine wave) is fed to the base of TR502, and the triggering level, set by the LEVEL control, is as indicated by EL in Figure 4–21, TR502 is cut off and TR503 conducts at time 0. When the trigger signal level increases and exceeds the trigger point +EL(t_1), TR502 conducts, causing TR503 to cut off. When the trigger signal level again becomes more negative than the triggering level EL (t1), TR502 shuts off and TR503 conducts.

When TR502 is cut off, tunnel diode D509, which is connected in series with TR502, is placed in its low-voltage region as shown in Figure 4–22. Only a very small amount of DC current flows through TR505 as its emitter is connected to a high resistance, R538 (22 kilohms), and it is isolated from other circuits by C516. When TR502 changes from off to on, a current larger than Ip of D509 (4.7 mA) flows through the tunnel diode to drive the tunnel diode into its high-voltage region. Since the cathode of D509 is kept more negative than the power source and the voltage across the tunnel diode rapidly increases when it goes into the high volt region, the transition causes a rapidly changing current flow through C516 and TR505 and drives the pulse transformer. A positive pulse, the width of which is determined by C516, is obtained from the collector of TR505.

When TR502 turns off, the current flowing through D509 becomes smaller than I (0.45 mA) and the operating point of the tunnel diode steps to the low voltage region causing a negative pulse output at the collector of TR505. The polarity of the positive and negative pulses are inverted by pulse transformer T500. The negative pulse (trigger pulse) from the transformer is used to drive the succeeding A sweep generator.

Timing of the negative pulse, or the transition of TR502 from off to on, is shown as t1 and t3 in Figure 4–21. By adjusting the LEVEL control, the trigger pulse can be generated at a selected point on the positive-going slope of the trigger signal. Since the input trigger signal fed to the base of TR502, and the amplified input signal fed to the deflection plates of CRT, are in phase, the sweep can be triggered from an optional point on the positive-going slope

Figure 4–19 Block Diagram of B Trigger Generator



of the input signal waveform.

Next, consider the SLOPE switch set to (–).

In this case, the switch connections to D505 through D508 are reversed from those when the SLOPE switch is at + position and the current through D509 flows into TR503. If a trigger signal similar to that previously described is applied, and the trigger level is set to EL, switching of TR502 through TR503 is in the opposite phase from that with SLOPE in (+). The current through D509 is controlled by TR503. The base waveform of TR505 is in the opposite phase to that with + SLOPE position and trigger pulses can be generated at timing t2, t4 —— Then, the sweep can be from a selected point on the negative-going slope of the input signal waveform.

Trigger Signal/Horizontal Signal Switching Circuit

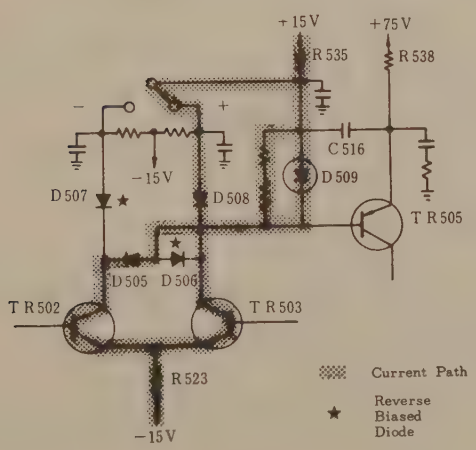
A switching circuit composed of a diode and a switch is provided between the input source follower and the emitter follower. The function of this circuit is to switch the trigger signal or the horizontal signal to the succeeding circuit.

When the HORIZ DISPLAY switch is set at the A position, –15 volts is applied to R518, D503 turns on and D502 turns off, and the trigger signal is not fed to the shaping circuit.

When the HORIZ DISPLAY switch is set at A INTEN BY B or DLY' (B) position, D503 turns off. During this time D502 repeats the on and off action with the DLY'D (B) MODE switch. In other words, when this switch is set at the TRIG'D position, D502 turns on and the trigger signal is fed to the shaping circuit. In the AUTO position, D502 turns off.

When the HORIZ DISPLAY switch is set at the EXT HORIZ position, D502 and D503 turn off and D501 turns on. Consequently, the horizontal input signal connected to the TRIG OR HORIZ INPUT connector is fed to the horizontal signal amplifier.

Figure 4–20 Current Flow in Shaping Circuit (when the SLOPE switch is set at the +position)



Horizontal Signal Amplifier

The horizontal signal amplifier is a negative-feedback amplifier to which an emitter follower TR507 and amplifier TR508 are connected. Part of the output from TR508 is fed back to the base of TR507 through R550. The amplified horizontal signal is fed to the horizontal pre-amplifier.

Figure 4–21 Trigger Signal and Trigger Pulse (when the SLOPE switch is set at the +position)

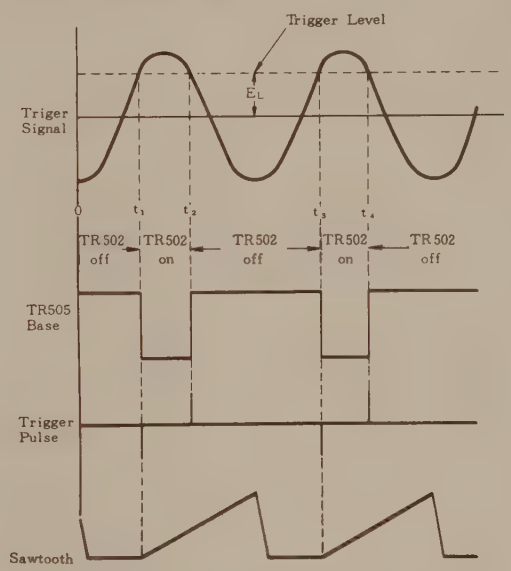
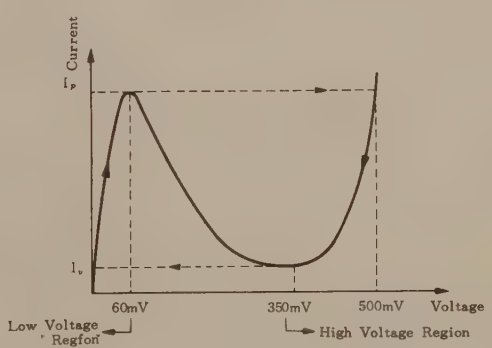


Figure 4–22 Tunnel Diode Characteristics (D509)



▷ B Sweep Generator

The B sweep generator circuit is shown in Figure 4–23. The basic concept of this circuit is similar to the A sweep generator circuit. The B sweep generator is actuated only when the HORIZ DISPLAY switch is set to the A INTEN BY B or the DLY'D (B) position, to generate the following 4 types of signals.

(1) Sawtooth Wave
(2) Unblanking Signal
(3) Gate Pulse
(4) Alternate Signal

A Inten by B Operation

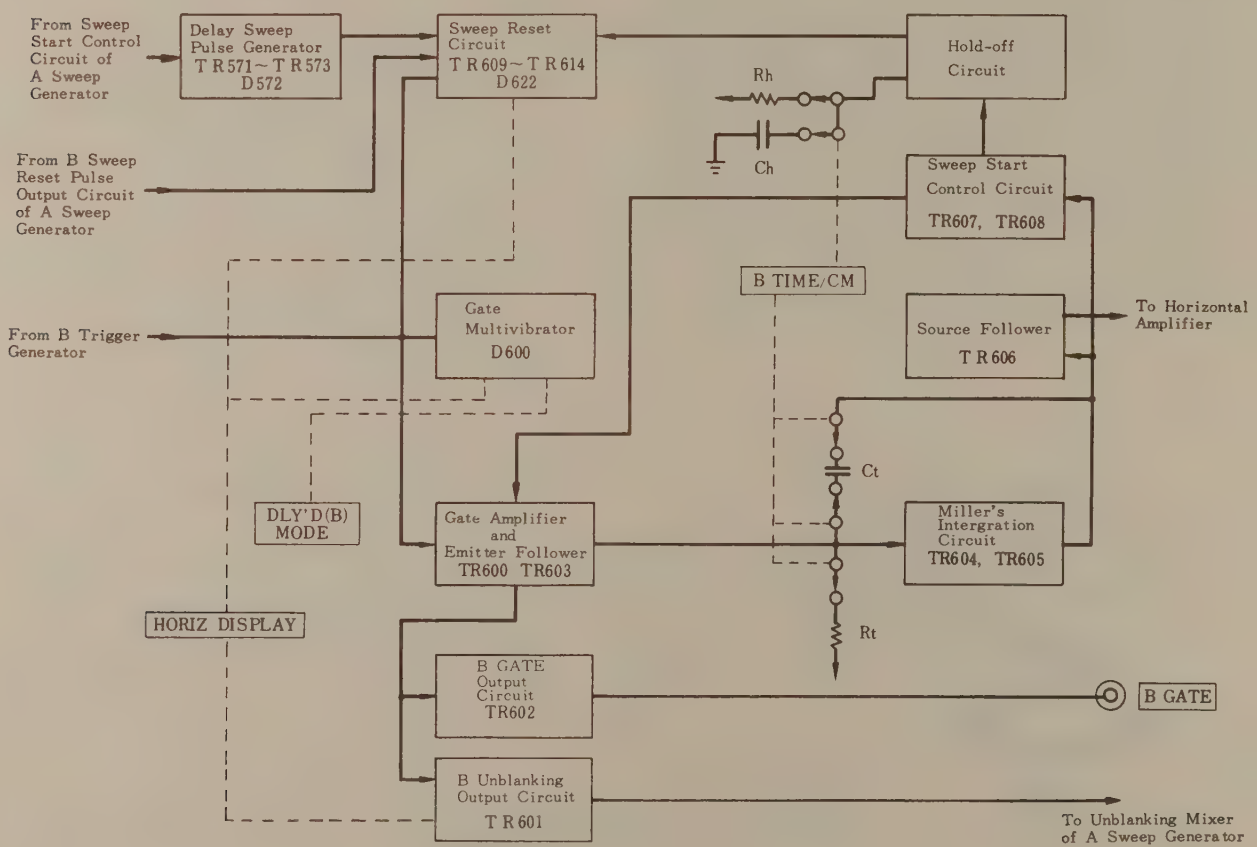
Basic operation of the A INTEN BY B mode is similar to that of the single sweep operation in the A sweep generator. The B sweep circuit, in this case, is actuated by the A sweep signal.

The condition required to actuate the A or B sweep generator is driving the tunnel diode, D421 or D622, to its high-voltage region. In other words, the sweep is deactivated by placing the tunnel diode in its low-voltage region. The circuit from TR401 in the A sweep generator to TR614 and D625 in the B sweep generator is used to inhibit the B sweep, based on this principle.

In the A INTEN BY B (and DLY'D (B) sweep which will be described later) operation, the B sweep always starts after the A sweep, however the duration of the two sweeps usually differs. When the A sweep ends before the B sweep, the B sweep is terminated with the end of the A sweep. A case where the B sweep ends faster than the A sweep will not be described. Waveforms in this mode of operation are shown in Figure 4–24. The B sweep generator, as previously described, operates similarly to the single sweep operation in the A sweep. The delay pulse in the B sweep mode corresponds to the reset pulse in the A sweep operation.

A sawtooth wave is supplied from the A sweep generator to the delay sweep pulse generator, or the base of TR571.

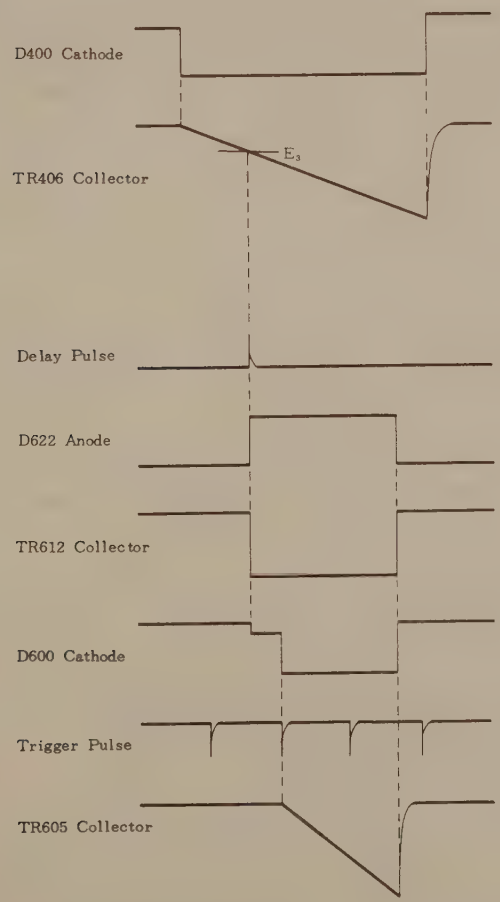
Figure 4–23 Block Diagram of B Sweep Generator


From Sweep Start Control Circuit of A Sweep Generator
Delay Sweep Pulse Generator TR571~TR573 D572
Sweep Reset Circuit TR609~TR614 D622
Hold-off Circuit
Rh
Ch
From B Sweep Reset Pulse Output Circuit of A Sweep Generator
Sweep Start Control Circuit TR607, TR608
B TIME/CM
From B Trigger Generator
Gate Multivibrator D600
Source Follower TR606
To Horizontal Amplifier
Ct
DLY'D(B) MODE
Gate Amplifier and Emitter Follower TR600 TR603
Miller's Intergration Circuit TR604, TR605
HORIZ DISPLAY
Rt
B GATE Output Circuit TR602
B GATE
B Unblanking Output Circuit TR601
To Unblanking Mixer of A Sweep Generator

Transistors TR571 compose a voltage comparator, with left side of TR571 conducting and right side of TR571 shut off, when the sawtooth wave reaches the amplitude indicated by (E3). The operating point of tunnel diode D572 steps to the low-voltage region, and the base potential of TR572 becomes negative causing its collector potential to become positive. This positive transition is differentiated by R581 and C573 through emitter follower TR573 and forms a positive pulse. The positive pulse, the timing of which is controlled by DELAY TIME MULTI-R575, is fed to the anode of D622.

The delay pulse drives D622 to its high-voltage region, causing the collector potential of TR612 to become negative. The operating point of D600 steps to point C in Figure 4–14 to reset the B sweep generator. The B sweep starts with a trigger pulse, but after one cycle of sweep operation is completed, the operating point of D600 returns to point A in Figure 4–14, and the circuit operation stops until another delay pulse is applied to reset the circuit. Triggered operation with the DLY'D (B) MODE switch is set to the TRIG'D position as follows. When the bias voltage of D600 is determined so that the operating point steps to point C in Figure 4–14 at the same time that D622 steps to its low-voltage region and shuts off TR612 at the end of a sweep, the sweep will be repeated, being triggered by the delay pulse regardless of the trigger pulse. This is the non-triggered operation which is performed when the DLY'D (B) MODE switch is placed in the AUTO position. The operation of the circuit, when the A sweep ends faster than the B sweep, will be described using non-triggered operation as an example. (Following this description, operation of the triggered operation will be easily understood.)

Figure 4–24 Waveforms in A INTEN BY B Operation



First, the A sweep starts, and the delay pulse actuates the B sweep. The operation of this circuit is the same as the aforesaid description until just prior to the end of the A sweep. At the end of the A sweep, TR400 shuts off and the collector of TR400 and the base of TR401 shuts off and the collector of TR401 is connected to the emitter of TR614 and its base potential is predetermined to be an intermediate value between the positive and negative potential on the base of TR401. Therefore, when the base of TR401 becomes positive, TR401 conducts and current flows through the common emitter resistor. When the base of TR401 becomes negative, TR401 is shut off, and the current flows through TR614. The negative change on the base of TR401 at the end of the A sweep, causes TR614 to conduct and drives D622 to its low voltage region through D625. TR612 shuts off, and its collector potential becomes positive to end the B sweep. In this manner, the B sweep ends simultaneously with the end of the A sweep.

DLY'D (B) (Delayed Sweep) Operation

The operation in the DLY'D (B) mode is substantially the same as that of the A INTEN BY B mode. The following explanations are for a case in which the DLY'D (B) MODE switch is set at the AUTO position ——— non-triggered delayed sweep. The DLY'D (B) sweep is of two types differentiated by the relative positions of the ends of the A and B sawtooth wave, i.e., when the end of the B sweep lags behind the end of the A sweep and vice versa. See Figure 4–25.

First, let us consider the case in which the end of the B sweep lags behind the end of the A sweep. Suppose sweep A begins and then sweep B is triggered by the delay pulse. The action up to the moment sweep B ends upon completion of sweep A is identical to the case in which "the end of sweep B lags behind the end of sweep A" in the A INTEN BY B mode. In the DLY'D (B) mode, as shown in Figure 4–25 (a), the B sawtooth wave which is terminated upon completion of sweep A ——— a sawtooth wave whose amplitude is smaller than that of E4 which is required to display a full trace on the viewing area of the CRT ——— is fed to the horizontal preamplifier, and since the sweep is made by this sawtooth wave, the length of a trace becomes shorter as its amplitude decreases. The slower the B sweep becomes as compared to the A sweep, the shorter the length of the trace gets. (However, since an expanded display of the input signal by the DLY'D (B) mode cannot be effected unless the B sweep rate is faster, it will not present any problem in actual measurements.)

Next, let us describe a case in which the end of the B sweep leads the end of A sweep. As shown in Figure 4–25 (b), since the B sawtooth wave is not terminated by the A sawtooth even if its slope is steep, the voltage is always maintained at a level of E4, and therefore the length of a trace will not become short.

▷ Horizontal Preamplifier

The circuit configuration of the horizontal preamplifier is shown in Figure 4–26. The function of this preamplifier is to amplify the A and B sweeps (sawtooth waves) or horizontal signals which are subsequently fed to the horizontal main amplifier.

Input Switching Circuit

The function of the input switching circuit is to open or close the diode gate in accordance with the positions of the HORIZ DISPLAY switch in order to feed the A and B sawtooth waves from the A and B sweep generators, respectively. This circuit also functions to feed the horizontal signals to the negative feedback amplifier when the instrument is used as an XY scope.

Negative Feedback Amplifier

The negative feedback amplifier consists of an emitter follower TR700, grounded emitter amplifier TR701 and a feedback loop. The feedback resistance is varied, thereby regulating the gain, by changing the positions of the HORIZ DISPLAY or MAG switch. In other words, when the HORIZ DISPLAY switch is set at a position other than the EXT HORIZ position and the MAG switch is set at X1, forward bias is applied to turning them on, and resulting in a parallel connection of feedback resistors R718 and R719 with R720 which decreases gain. When the MAG switch is set at X10, D706 through D709 turn off which causes the feedback loop to be formed by only R718 and R719, thereby decreasing the amount of negative feedback and the gain increases ten times as compared to the case in which the MAG switch is set at the X1 position. When the HORIZ DISPLAY switch is set at the EXT HORIZ position, the MAG switch position becomes irrelevant, and D706 through D709 turn off, thereby increasing the gain.

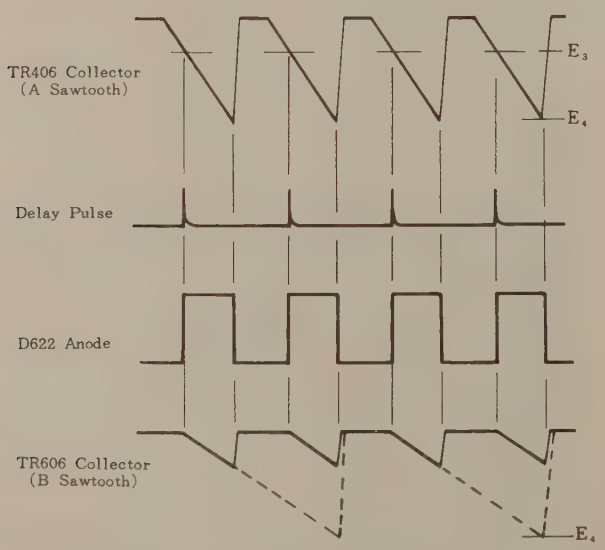
▷ Horizontal Main Amplifier

The circuit configuration of the horizontal main amplifier is shown in Figure 4–27. The function of this amplifier is to amplify the signal from the horizontal preamplifier to a level sufficient to drive the electron beam of the CRT.

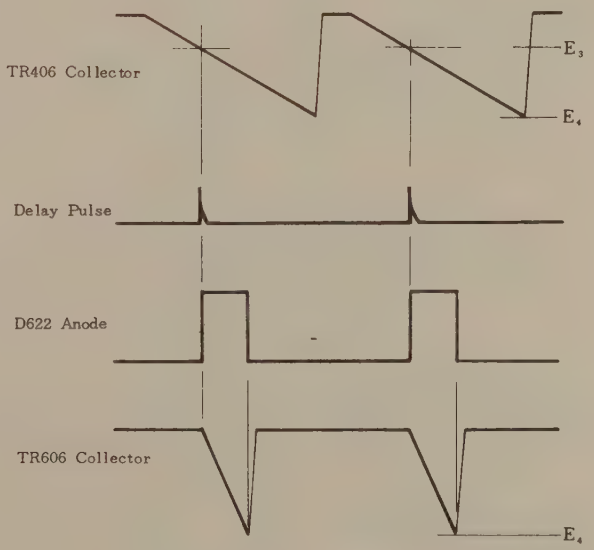
Input Amplifier

The input amplifier consists of a phase inverter TR750 and TR752, emitter follower TR751, for maintaining the DC balance of the phase inverter, and a constant-current circuit formed by TR753 and TR754, which is designed to provide constant current flow through TR750 and TR752 by increasing the impedance of the emitters of these

Figure 4–25 Waveforms in DLY'D (B) Operation (Non-triggered)



(a) The end of the B sweep lags behind the end of the A sweep



(b) The end of the B sweep leads the end of A sweep

transisors. Moreover, since the succeeding buffer emitter follower and output amplifier are composed of symmetrical PNP and NPN transistors, zener diodes are provided to match their DC levels.

The signal from the horizontal preamplifier is amplified by this phase inverter, converted into a balanced signal, and fed to the output amplifier.

Output Amplifier

The output amplifier consists of a negative feedback amplifier composed of a PNP transistor emitter follower TR755, emitter grounded amplifier TR756 and its feedback loop, and another negative feedback amplifier formed by NPN transistors TR757 and TR758 and the feedback loop. PNP and NPN transistors are used as these negative feedback amplifiers to improve the frequency response characteristics.

The function of the emitter follower composed of TR755 and TR757 is to drive the emitter grounded amplifier formed by TR756 and TR758 at low impedance which is to amplify the balanced signal. This amplification is further stabilized by the effect of negative feedback. D756, D757, D759 and D760 turn on when excessive balanced signal is applied to them, thereby preventing the delay of return trace time which is due to saturation of TR756 and TR758.

The circuit which is composed of TR759 through TR761 is a low impedance voltage regulator circuit which is to supply power to the emitter of TR756. TR759 and TR760 constitute an emitter follower to provide low impedance. Stabilization (regulation of voltage) is effected by feedback from the grounded emitter amplifier TR761.

Figure 4–26 Block Diagram of Horizontal Preamplifier

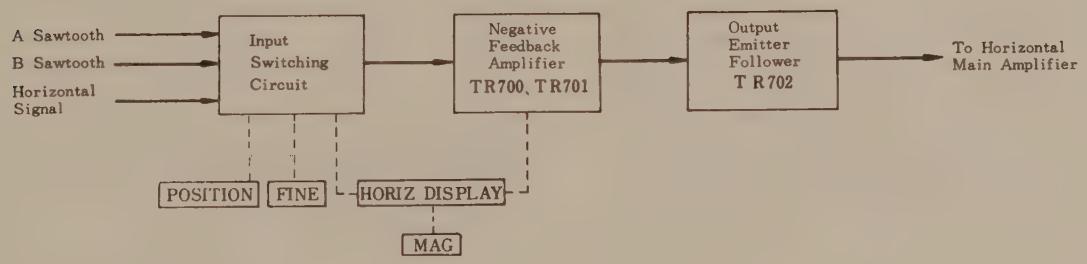
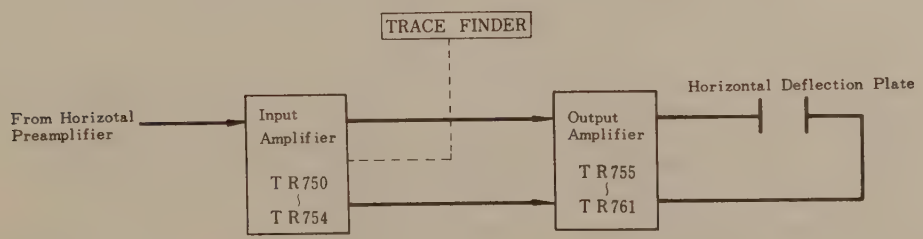


Figure 4–27 Block Diagram of Horizontal Amplifier



▷ Z Axis Amplifier

The Z axis amplifier circuit, shown in Figure 4–28, controls the intensity of the CRT display. The circuit amplifies, (1) the unblanking signals from the A sawtooth generator which unblank the trace during sweep time, (2) the chop blanking signals from the switching circuit which blank the trace during switching transients in the chopped sweep mode, and (3) external intensity modulation signals applied to the Z AXIS INPUT terminal. Operator control of the CRT display intensity is effected through the use of the INTENSITY control.

Pulse Shaper

The positive output pulses of pulse shaper circuit, a one-shot multivibrator (TR813 and TR814) triggered by the chop blanking signals, are used to blank CRT display transients in the chopped sweep mode. The chop blanking pulses are not used directly for this purpose since they are too narrow for the purpose. A positive chop blanking pulse applied to the base of TR814, through input coupling capacitor C811, causes TR814 to turn off. The negative collector voltage of TR814 is applied through C809 and R834 to the base of TR813, causing it to go into conduction. The positive going collector voltage of TR813, in turn, is applied through C810 back to the base of TR814 driving it further into cut-off. This regenerative action which continues until TR813 is saturated, and TR814 is fully cut-off takes a fraction of a micro-microsecond. C 810 then starts to charge through TR813, R836, and the power supply, gradually reducing the voltage at the base of TR814. When this voltage is sufficiently negative, TR814 conducts, turning TR813 off almost instanteously. The width of the output pulse is thus determined by the RC time constant of C810 and R836, and not by the trigger pulse. The pulse shaper circuit, therefore, acts to effectively lengthen the chop blanking signals to the required width for proper blanking.

Input Amplifier

The positive unblanking pulses are amplified and inverted by TR800 and applied to TR801, an emitter follower. The negative output pulses from TR801 are then fed to TR802 and TR803.

The positive chop blanking pulses from the pulse shaper are applied to the emitter of TR812, a non-inverting common base amplifier. The positive output pulses from TR812 are then fed to TR802 and TR803.

External intensity modulation signals from the Z AXIS INPUT terminal, are applied to TR811, another common base amplifier. The output pulses are then fed to TR802 and TR803.

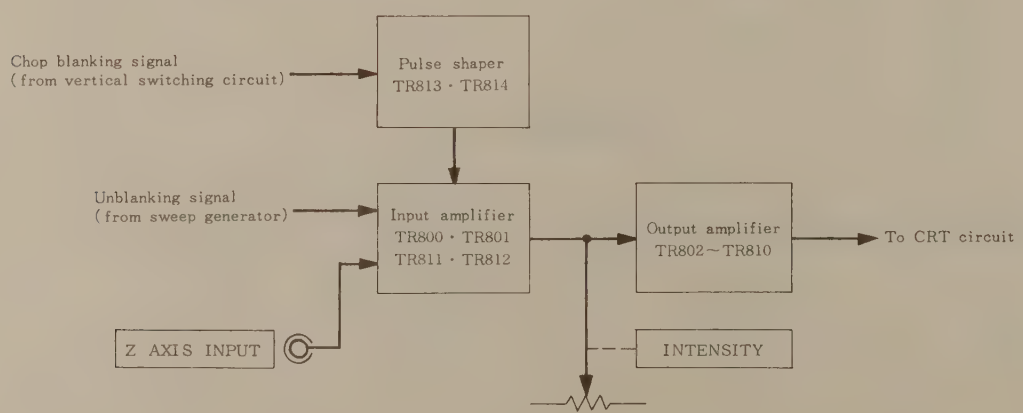
Output Amplifier

The INTENSITY control, R837, changes the input DC voltage level to the output amplifier, and consequently varies the intensity of the CRT display.

The output amplifier is basically a complementary amplifier with negative feedback. One half is composed of P–N–P transistors TR803 to TR809, and the other half is composed of N–P–N transistors TR802 and TR810. Negative feedback, used to improve the response of the amplifier, is accomplished by connecting the output (collectors of TR809 and TR810) back to the input (bases of TR802 and TR803) through resistor R810.

When a negative (unblanking or external modulation) pulse is applied from the input amplifier, TR803 conducts. The output from TR803 is applied, through TR804, to the TR805–TR809 chain, quickly driving them into conduction. The resulting positive pulse at the output thus has a sharp leading edge and TR802 and TR810 are at the same time, driven toward cut-off by the negative input pulse causing the voltage at the collector of TR810 to rise to a constant positive level. TR802 and TR810 return to their quiescent (conducting) state at the end of the input pulse, and the collector voltage of TR810 quickly returns to the

Figure 4–28 Block diagram of Z-axis amplifier



normal level. The positive output signal is thus essentially a square wave.

When a positive (chop blanking or external modulation) pulse is applied, the operation of the output amplifier is reversed, resulting in a negative going output pulse.

Positive output pulses of high amplitude are required for CRT unblanking and intensity-control purposes. By series connecting transistors TR805 to TR809, this requirement is met without exceeding the rated collector breakdown voltage of the individual transistors. The negative output pulses, on the other hand, do not have to be of high amplitude as they are used for CRT blanking only. One output transistor, TR810, is therefore sufficient.

▷ CRT Circuit

The configuration of the CRT circuit is shown in Figure 4–29. This circuit produces the high voltages required to emit and accelerate the electron beam in the CRT. The high voltages are produced by converting the unregulated power source (approximately 25 V) oscillator. The sine-wave output is stepped up by high-voltage transformer T901, and rectified by the high-voltage rectifier (quadruple voltage rectifier) and the control grid voltage rectifier (half-wave rectifier).

High-Voltage Osillator

The high-voltage oscillator is composed of TR903, the primary winding of T900, and C903. When the POWER switch is turned on, current flows through the collector and primary winding of T900. This current induces an electromotive force in the winding connected to the base of TR900 and causes the base potential of TR903 to rise in a positive direction. This increases collector current and causes capacitor C903 to charge negative. The collector current increases until it saturates and the electromotive force stops. The charge on C903 decreases the base potential of TR903 and its collector current and the collector potential of TR903 rises. The direction of the electromotive force is then reversed, and C903 is charged positive until it reaches a point where TR903 conducts. The operation is repeated and the circuit oscillates at 30 kHz.

Control Grid Rectifier

The control grid rectifier supplies approximately −1500 V to the control grid of the CRT, and feeds the intensity control signal from the Z axis amplifier to the control grid.

The stepped-up voltage across terminals #5 and #6 of T900 is half-wave rectified by D901 and filtered by C904.

Neon tubes, NE900, NE901, and NE902, are used to protect the CRT. These neon tubes conduct when an excessively high voltage appears between the cathode and control grid of the CRT.

High-Voltage Rectifier

The high-voltage rectifier supplies an electron beam accelerating voltage of approximately +13.5 kV, to the accelerator, and approximately −1450 V to the cathode.

The stepped-up voltage across terminals #7 and #9 of T900 is rectified by a quadruple voltage rectifier circuit consisting of D903 – D906 and C906 – C909, to supply the +13.5 kV. The voltage across terminals #7 and #8 is half-wave rectified by D903 filtered by C917, and is supplied to the cathode of the CRT.

Figure 4–29 Block Diagram of CRT Circuit

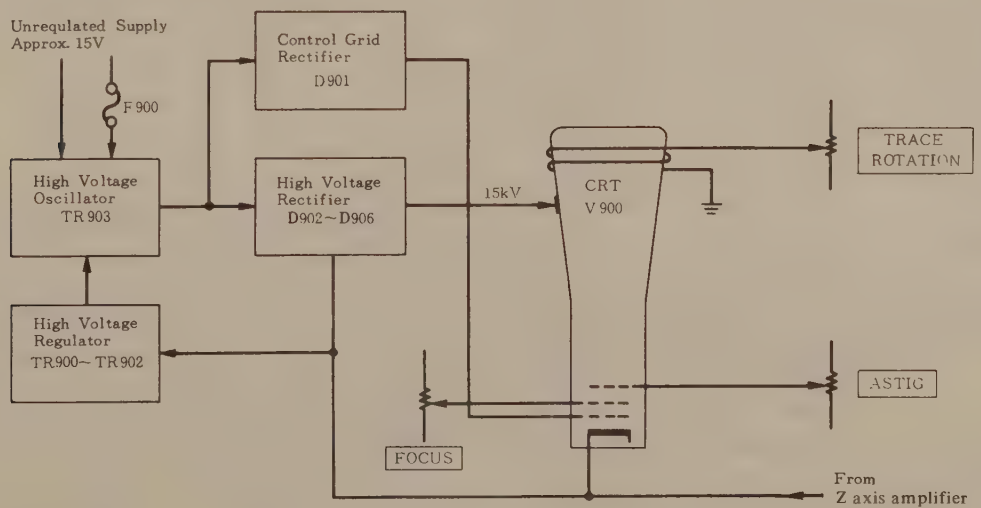
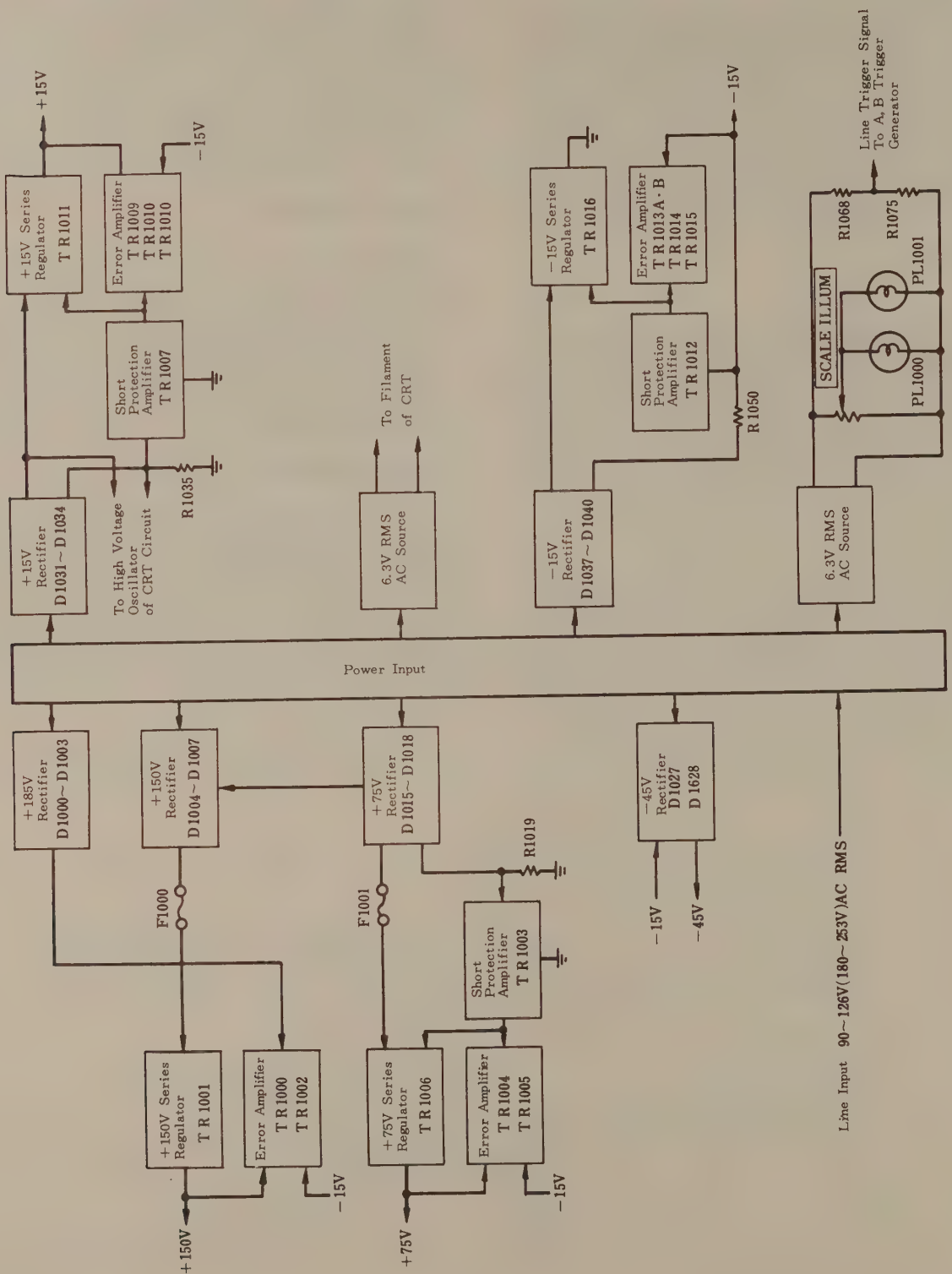


Figure 4–30 Block Diagram of Low-Voltage Power Supply



High-Voltage Regulator

In order to keep the DC output voltage at a constant level, the high-voltage regulator feeds part of the DC output back to the high-voltage oscillator.

Assume that the cathode potential is reduced due to a variation in the load. This voltage variation is detected by error amplifier, TR900 and TR901 and causes a positive rise in the collector potential of TR903. The collector voltage variation causes the emitter potential of TR902 to rise, and increases the base current of TR903. The collector current of TR903 increases and increases the high voltage until the DC output reaches the initial level. H.V. ADJ R901 controls the potential on the base of TR900 to control the amplitude of oscillations.

▷ Low Voltage Power Supply

Configuration of the power supply circuit in shown in Figure 4–30. The power supply consists of three regulated power supplies and 6.3 V RMS AC source.

Power Input

Power is applied to transformer T1000 through POWER switch S1000, LINE VOLTAGE RANGE switch S1002 and THERMO CUTOUT S1001. When this instrument is used on an AC 100 V line, the two primary windings of T1000 are connected in parallel. In the LOW position of the LINE VOLTAGE RANGE switch, windings #1 – #2 and #4 – #5 are connected in parallel, and in the HIGH position of the switch, windings #1 – #3 and #4 – #6 are connected in parallel. When the instrument is used on an AC 200 V line, the two primary windings are connected in series, as shown by the dotted line in the circuit diagram.

If the internal temperature of this instrument becomes excessively high, THERMO CUTOUT S1001 operates to disconnect the power supply. This switch automatically restores when the instrument temperature returns to normal.

–15 V Supply

The –15 V supply is used as the reference voltage for the other power supplies. The voltage from the secondary winding (across terminals 13 – 14) is rectified by bridge rectifier D1037 – D1040 and filtered by C1033. The output of the filter is fed to the –15 V series regulator TR1016. The series regulator may be described as a variable resistor controlled by the output of the error amplifier.

The error amplifier is a voltage comparator of which the approximately –8.5 V reference voltage on the base of TR1013A is determined by D1036. The potential on the base of TR1013B is determined by the voltage divider, composed of R1061, R1062 and R1063. R1063 is a variable resistor which is used to adjust the –15 V output voltage. R1035 is connected to the emitters of both TR1013A and B. The collector current of TR1013 flows through TR1014 and TR1015 and controls the series regulator, TR1016. The current in TR1016 varies to supply the low ripple –15 V regulated voltage. By turning variable resistor R1062 in the direction indicated by the arrow, the current through TR1013B increases, that through TR1013A decreases, and the currents through TR1014 and TR1015 increase. Finally the current through TR1016 increases and output voltage rises.

In order to supply a constant voltage to the load, a portion of the output voltage is fed back, through the error amplifier to the series regulator. For example, if the –15 V output rises due to variation in the load or line voltage, this increase raises the base potential of TR1013B through the voltage divider. This increase in base potential causes the emitter voltage to become more negative, and the collector of TR1013A becomes more negative. The emitter voltages of TR1014 and TR1015 also decrease to reduce current through TR1015. Finally, the output voltage decreases until it reaches –15 V.

Transistor TR1012 protects the series regulator TR1016 if the –15 V output is shorted to ground. Normally, TR1012 is shut off, but if a large current flows through R1050 due to a short circuit in the –15 V output, the voltage drop across R1050 causes the emitter of TR1012 to become negative, allowing the transistor to conduct. TR1014 and TR1013 are shut off, and protect TR1016 from excessive current.

+15 V Supply

The DC voltage rectified by bridge rectifiers D1031 – D1034 is filtered by C1024, and is supplied to the +15 V series regulator and CRT high-voltage oscillator circuits. The regulated –15 V is used for the reference voltage of the +15 V circuit. The +15 V and the –15 V outputs are divided by resistors R1043, R1044, and R1045, and the divided output is fed to the base of TR1008. If variation occurs in the +15 V output, the variation is amplified by error amplifier TR1008, TR1009, and TR1010, and is fed to the series regulator TR1011 to regulate the output voltage. Diode D1035 is a thermal compensator whose temperature coefficient is determined to compensate for thermal variations of the TR1008 bias voltage source.

TR1007 also protects TR1011 from excessive current due to short circuits in the +15 V output circuits. The operation of R1035 is identical to that of R1050 in the –15 V supply.

+75 V Supply

The basic operation of the +75 V supply is identical to that of the +15 V supply.

Diode D1021 is normally shut off, and conducts only if a short circuit occurs in the +75 V output circuit. This diode functions to reduce the base potential of TR1005 and prevent excessive current in TR1006.

+150 V Supply

The output of the +150 V rectifier is superimposed on the output of the +75 V rectifier to provide a voltage of approximately 200 volts. This voltage is applied to the collector of the series regulator TR1001, regulated by the error amplifier composed of TR1000 – TR1002, and reduced to a voltage of +150 V. The power which is

required to drive the error amplifier is provided from the +185 V rectifier. The protection circuit, in case the +150 V supply is shorted, shares short-circuit protection device TR1003 which is provided for the +75 V supply.

The operation of the +150 V supply circuit is basically the same as the operation of the +75 V supply circuits.

6.3 V RMS AC Source

Two 6.3 V RMS AC source circuits are provided; one is for the CRT filament and the other is for the scale illumination light PL1000 and PL1001 and is also used as the line trigger signals for the A and B trigger generator.

–45 V Supply

The output of the rectifier D1028 is smoothed by a filter composed of R1033 and C1023 and superimposed on a voltage of –15 V to provide a voltage of –45 V which is applied to the CRT circuit.

▷ Calibrator

Figure 4–31 shows the circuit configuration of the CALIBRATOR (calibration voltage and current oscillator) which generates square-wave voltage and current of highly accurate frequency and amplitude.

Oscillator

The calibrator oscillator is composed of two transistors, TR1101 and TR1102. Oscillation frequency is determined by the collector winding of T1100 and capacitor C1103.

High stability is obtained by employing low temperature coefficient components in this circuit. Oscillations of the LC circuit (T1100 – C1103) are sustained by the feedback winding of T1100 connected to the base of TR1101. The oscillator output is fed to the base of TR1102, through C1104, and the emitter is fed back (positive) to the emitter of TR1101 to accelerate the rise time of the output square-wave. The oscillator frequency is adjusted by varying the inductance of T1100. The square-wave output of TR1102 is then fed to the output amplifier.

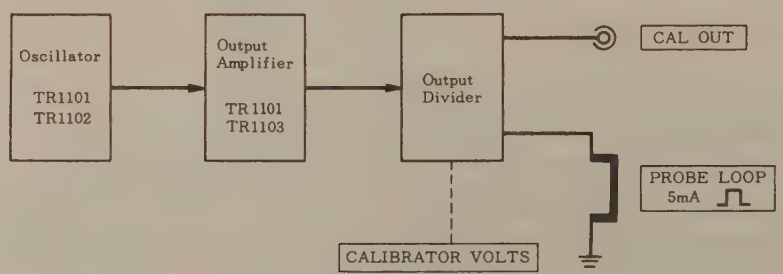
Output Voltage Divider

The square-wave signal drives the output amplifier, TR1103, to saturation and cutoff. In other words, when the base of TR1103 steps positive, TR1103 is shut off, and its collector potential becomes zero. On the other hand, when the base becomes negative, TR1103 saturates causing its collector to become approximately 10 V (the collector voltage of TR1103 at saturation is adjusted with screwdriver adjust potentiometer CAL ADJ). Emitter follower TR1100 supplies power to the emitter of TR1103 and collectors of TR1101 and TR1102.

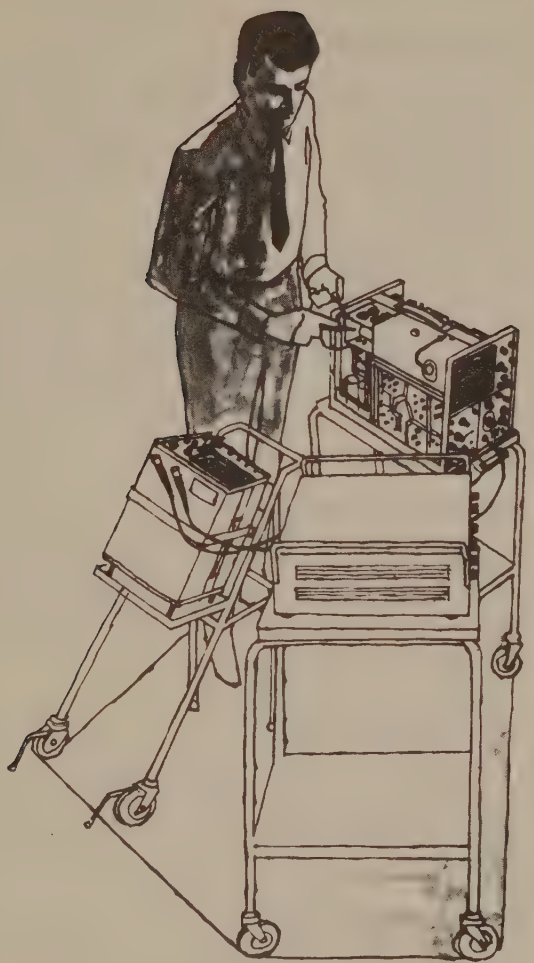
Output Voltage Divider

The collector current of TR1103 flows through the voltage dividing resistors and the PROBE LOOP. The current through the PROBE LOOP is a 5 mA square-wave. The TR1103 output voltage is divided and supplied to the CAL OUT connector through the CALIBRATOR VOLTS switch.

Figure 4–31 Block Diagram of Calibrator



CHAPTER 5 MAINTENANCE



In this chapter, maintenance procedures which will ensure optimum operation of this instrument for a long period are described. If testing or replacement of parts is required, refer to the circuit and printed-circuit board diagrams.

In addition to proper maintenance, a thorough understanding of instrument performance and proper operation (Chapter 2 "Pre-Start Operation" is important) are essential to ensure optimum performance.

Preventive Maintenance 5–2
Troubleshooting..... 5–2
Parts Replacement 5–5

▷ Preventive Maintenance

The maintenance procedures listed herein outline periodic tests which insure reliability of the instrument and indicate the preventive maintenance measures to be taken when required.

When the instrument is used under severe ambient conditions, the preventive maintenance procedures presented in this manual should be performed repeatedly.

Cleaning

The instrument should be kept clean at all times. Dust accumulating in the instrument affects the radiation of heat and may cause overheating and the subsequent failure of parts. Foreign substances on contacts or connectors result in poor contact, and on printed circuit boards, may cause arcing in damp climates or seasons. Suitable cleaning agents are listed in Table 5-1. Those agents indicated as unsuitable must not be used.

Table 5–1

Suitable cleaning agents	Alcohol and xylene
Unsuitable	Acetone, methyl-ethyl-ketone, ether, lacquer thinner, and chemicals containing ketone series solvents.

Front Panel Cover

Ordinary dirt on the front panel cover can be removed by washing the cover with a mild detergent. When grease or oil is present, use a soft cloth and one of the preferred cleaning agents listed in Table 5-1.

Front Panel and Knobs

Clean the front panel and the knobs with a damp cloth and a detergent or a suitable solvent. Use of alcohol may result in slight discoloring of the panel. If a powdered cleanser is used, wipe off any cleanser which remains after drying.

Dirt in Instrument

The best way to remove dirt or dust inside the instrument is to blow it out with air under pressure. Use of a soft brush in conjunction with the air will aid in the cleaning.

Dirt on CRT Surface

If the CRT filter is left off for a long time, the face of the CRT may become dirty. Dust or fingerprints can be removed by wiping the surface with a soft cloth. Stains or sticking dirt can be removed with alcohol or detergent.

Filter

Remove dust with a soft brush or smooth soft cloth such as a nylon stocking. Grease or sticking dirt should be removed with a mild detergent and warm water. After cleaning, rinse the filter in water and dry it thoroughly.

Visual Inspection

A simple visual check of the inside of the instrument will sometimes reveal various detects, such as charred resistors, defective contacts, or broken circuit boards. Immediate repair of these minor defects will prevent more serious troubles.

Check of Semiconductors

When the performance of transistors, diodes or other conductors is suspect, a transistor curve tracer or other special measuring instruments should be used for checking semiconductors. A multimeter (VOM) must not be used to check tunnel diodes since internal current of the multimeter will cause the diode to fail.

When The Instrument is to be Left Idle

When the instrument is not going to be used for a certain period, disconnect the probe and adaptor from the panel and cover the instrument with the protective dust cover. Store the accessories in the accessory box and place the instrument in a dry place.

▷ Troubleshooting

A thorough understanding of the overall system and circuit operation of this instrument will prove to be a valuable aid in troubleshooting. For this purpose, refer to Chapter 4 "Circuit Description."

Troubleshooting References

Circuit Diagrams

The circuit diagrams are classified in accordance with the blocks shown in Figure 4-1 "Basic Block Diagram." Circuits enclosed by the dotted lines in the block diagram are on printed circuit boards.

The location of contacts and wafers of each rotary switch are also indicated. Contact positions on the side of a wafer closest to the front panel are denoted as A-F, and those on the rear side of the front wafer are A-R. Subsequent wafers are indicated as B-F and B-R. Concentric shaft switches are described as aA-F, aA-r,.... (switch closest to front panel and driven by the outer shaft) and bA-F, bA-R,.... (rear switch, driven by the inner shaft).

Voltages and waveforms measured during normal operating conditions are indicated on the diagram. Since these voltages and waveforms will vary depending upon the position of relevant controls, these points should be measured with the controls set as stated.

Location of Circuit Boards

The circuit arrangement diagrams in the last section of this manual show the location of circuit boards, and will help in checking these circuits.

Parts Arrangement Diagrams

The parts arrangement diagrams on the PC boards in the last section will aid in checking or replacement of parts.

Wiring Color Code

Wires are color-coded according to their function. Two-color wires are for the power supply circuits, and single color wires are used for the general circuit wiring. The color code of wires is shown in Table 5-2 and Table 5-3. Table 5-3 shows a typical use of wires, therefore, some wires in this instrument may deviate from the code. Shielded wires are not included in these codes.

Resistor and Capacitor Color Code

The resistors and capacitors used in the circuit are colorcoded as shown in Figure 5-1.

Indentification of Diode and Transistor Elements

Element identifying marks for the various diodes and transistors are shown in Tables 5-4 and 5-5.

Table 5—2 Color Code of Power Supply Wires (Two-Colored)

Low Voltage Source	Base Color	Stripe Color
−15 V	White	Black
+15 V	White	Red
+75 V	Red (White in plug-in unit)	Blue
+150 V	Red (White in plug-in unit)	Yellow

Table 5—3 Color Code of General Wiring (Single Color)

Circuit	Color
Collector or drain wires	Red
Base or gate wires	Yellow
Emitter or source wires	Blue
Positive voltage wires	Brown
Negative voltage wires	Purple or gray
Others (signal line, etc.)	White
Ground wires	Black

Measuring Instruments Required for Troubleshooting

The following instruments are required for troubleshooting.

(1) Multimeter
- Input Impedance : 10 megohms
- Voltage Range : Normal range 0-300V (measurable to 2 kV)
- Resistance Range : 0-20 megohm

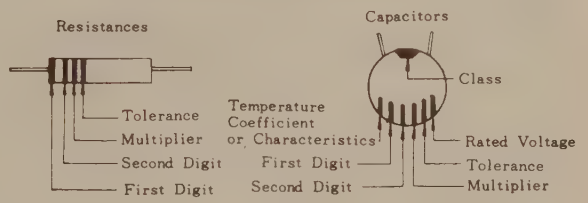
(2) Transistor Curve Tracer
IWATSU Transistor Curve Tracer TT-502, TT-505 or equivalent

(3) Synchroscope
- Bandwidth : DC-50 MHz
- Sensitivity : 5 mV/cm

Prior to Troubleshooting

First, it should be determined whether the instrument is actually defective, or other external conditions are responsible for the trouble indications. For example, when the power source voltage exceeds the allowable operating range, or external noise is induced in the test set-up, the display will become irregular.

Figure 5—1 Resistor and Capacitor Color Code



Color	Resistance or capacitance value: 1st and 2nd significant digits	Resistance or capacitance value: Multiplier	Tolerance for resistance (%)	Tolerance for capacitance %: 10 pF or more	Tolerance for capacitance %: 10 pF or less	Rated voltage (Capacitor)
Black	0	1	—	±20.0	± 2.0	—
Brown	1	10	± 1	1.0	—	—
Red	2	10^2	± 2	± 2.0	—	250 V
Orange	3	10^3	—	± 2.5	—	300 V
Yellow	4	10^4	—	—	—	—
Green	5	10^5	—	± 5.0	± 0.5	500 V
Blue	6	10^6	—	+ 100 (− 0)	—	—
Purple	7	10^7	—	—	—	—
Gray	8	10^8	—	±10.0	±0.25	—
White	9	10^9	—	—	± 1.0	1000 V
Gold	—	10^{-1}	± 5	—	—	—
Silver	—	10^{-2}	±10	—	—	—
Not colored	—	—	±20	—	—	—

Table 5–4 Type and Element Identification of Diodes

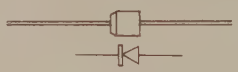
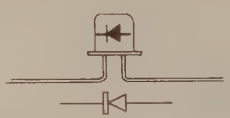
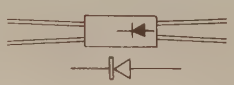
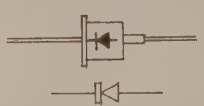
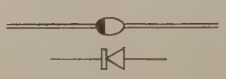
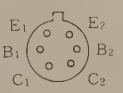
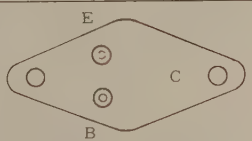
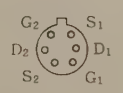
Type	Element Identification
1S 953, 1S 955 RD type HW type 1N 754A, 1N 750A 1S1992, 1S1544 SD 18, SD 104	
10D2	
1S1458	
5EH–4 5EH–12	
1S552	
SD11F	
Tunnel Diode TD717 1S1760	
RD29B	
HF–SD–1	
V03C V06G	

Table 5–5 Type and Element Identification of Transistors

Type	Element Identification
2SC350H 2SC907HC 2SC650B	
2N4121 2N4122 2N4258 2N4275	
μPA–15	
Power Transistors 2SD198, 2SC1030 2SD 91, 2SD 93	
Other Transistors	
2N4360	
2SK12–GR 3SK23	
2N4223	
TIS27	
MK10–2	

When the display at a certain sweep rate is somewhat irregular and it is difficult to determine whether the instrument is defective, it is advisable to observe another type of signal and see if the same irregularity occurs.

Troubleshooting Procedure and Sequence

The following procedures and sequence of troubleshooting will help to save time.
(1) Before removing the covers from the instrument, verify all control functions described in Chapter 2, "Operating Procedures." This should aid in isolating the defective portion to a particular circuit such as the low-voltage power supply, CH 1 preamplifier, CH 2 preamplifier, trigger generator and so on.

Table 5-6 outlines the proper steps for checking operation of the instrument and localizing the cause of malfunction.

Follow the steps starting from the top left of the table, and proceed to the next step along the vertical arrows in the leftmost column when instrument operates as indicated. If not, route the horizontal arrows rightward. Check procedures and possible cause of the trouble are given in the right hand columuns.
(2) Next remove the cover on the side of the instrument which contains the suspicious circuit, and visually check components, wires, and the circuit pattern for irregularities such as charred wires or resistors, defective contacts or broken wires. Various causes of trouble may be detected by a thorough visual inspection.
(3) Check the low and high voltage supplies. (Refer to Chapter 6 "Low and High Voltage Supplies.") Trouble in the low-voltage power supply has considerable influence on other circuits. Abnormal voltage from power supplies must be corrected.
(4) Next, use a multimeter or test synchroscope to check the operation of individual circuits, referring to the circuit diagrams in the last section, and localize the defective circuit.
(5) Check the characteristics of suspicious active elements (transistors or diodes) and passive parts (resistors or capacitors, etc.), and replace any defective part(s) with new one. Note that a number of parts may be defective in a circuit.

▷ Parts Replacement

Precautions on inspection and replacement of parts will be described in this section.

Ordering Information

When ordering parts for replacement, contact IWATSU or the representative in your area, referring to the parts list given at the end of this manual for proper part numbers and other information.

Before Replacing Parts

Before replacing parts, be sure to disconnect the power cord from the line. Handle the high-voltage circuit with extreme care.

Removal of Covers

The side cover can be removed by turning the two locks on each panel in the direction marked OPEN. The bottom cover can be removed by removing the four screws located below the side covers. Moreover, remove the rear cover and open the radiator panel to find internal circuits such as unblanking amplifier, blanking amplifier and low-voltage power supply.

Removal of Vertical and Horizontal Plug-In Units

Remove the left, right, and bottom covers. The vertical axis plug-in unit can be removed after taking out the screws located in the rear or in the rear and bottom The horizontal axis plug-in unit can be pulled out by removing screws from the rear or the bottom panel. The mounting positions of screws on these units may differ with the serial number, or date of manufacture, of the instrument.

Replacement of Semiconductor Elements

Suitable transistors or diodes must be used for replacement. Selected transistors are employed in major circuits of this instrument in order to ensure the characteristics described in Chapter 1. These selected transistors are shown in Table 5-7.

The semiconductors are sensitive to heat. When the transistor leads are soldered, use heat sinks to prevent the conduction of heat to the actual internal elements. Replace parts as quickly as possible as heat may cause the printed circuits to separate from the laminate.

Table 5—7 Selected Transistors

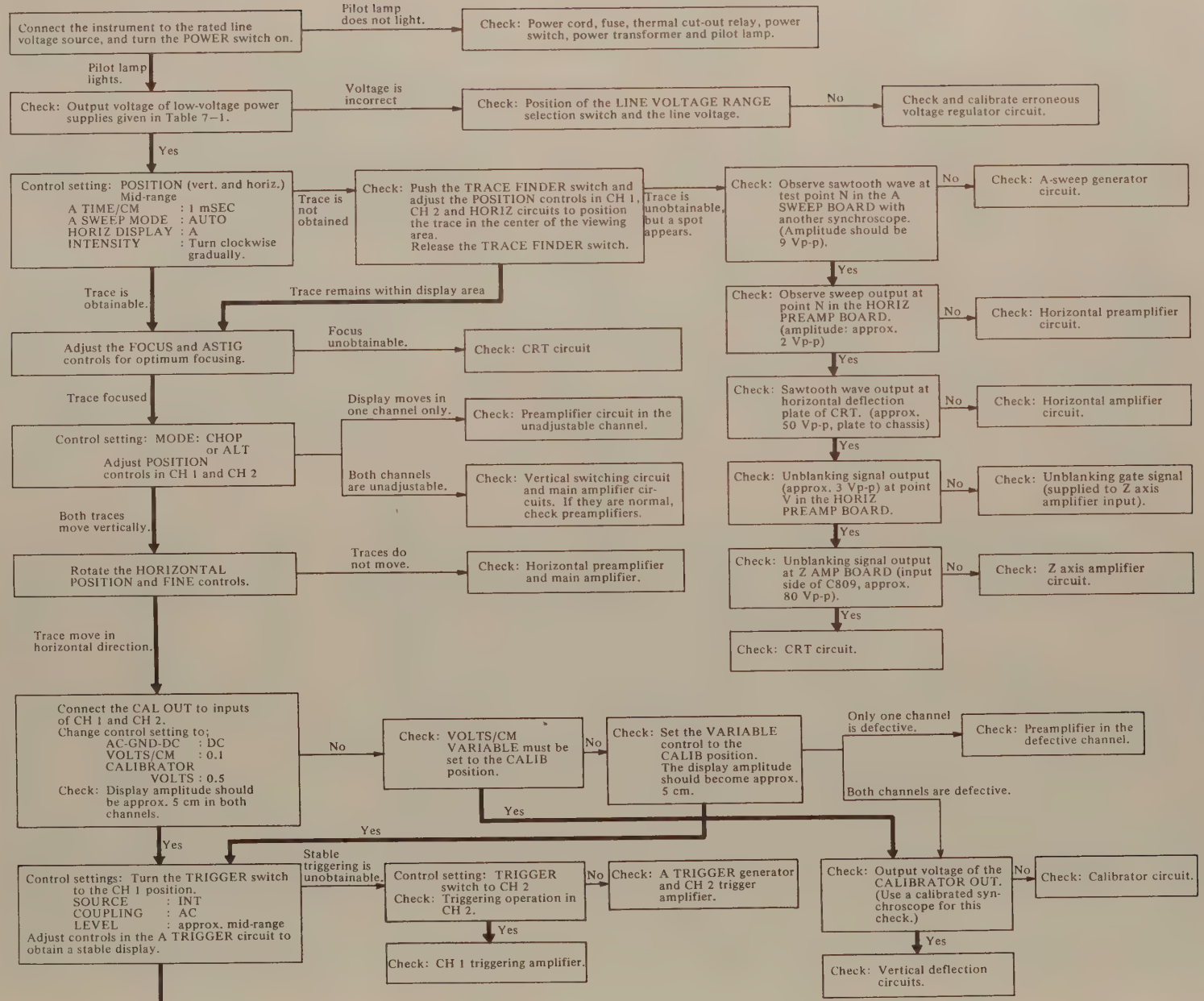
Circuit	Circuit No. of Transistors
CH 1 PREAMPLIFIER	TR42A(TIS27), TR47A · TR48A · TR65A · TR66A · TR117A · TR118A(2N3571), TR74A · TR75A · TR95A · TR96A(MK4049) TR87A · TR89A(2N4260)
CH 2 PREAMPLIFIER	TR42B(TIS27), TR47B · TR48B · TR65B · TR66B · TR117B · TR118B(2N3571), TR74B TR75B · TR95B · TR96B(MK4049) TR87B · TR89B(2N4260)
SWITCHING CIRCUIT	TR131 · TR132 (2N3571)
TRIGGER AMPLIFIER	TR150A/B · TR151A/B · TR161A/B TR162A/B(2N5179) TR173A/B · TR174A/B · TR179 TR180 (2N4260)
A SWEEP GENERATOR	TR405 (2SK12—G)
B SWEEP GENERATOR	TR604 (2SK12—G)

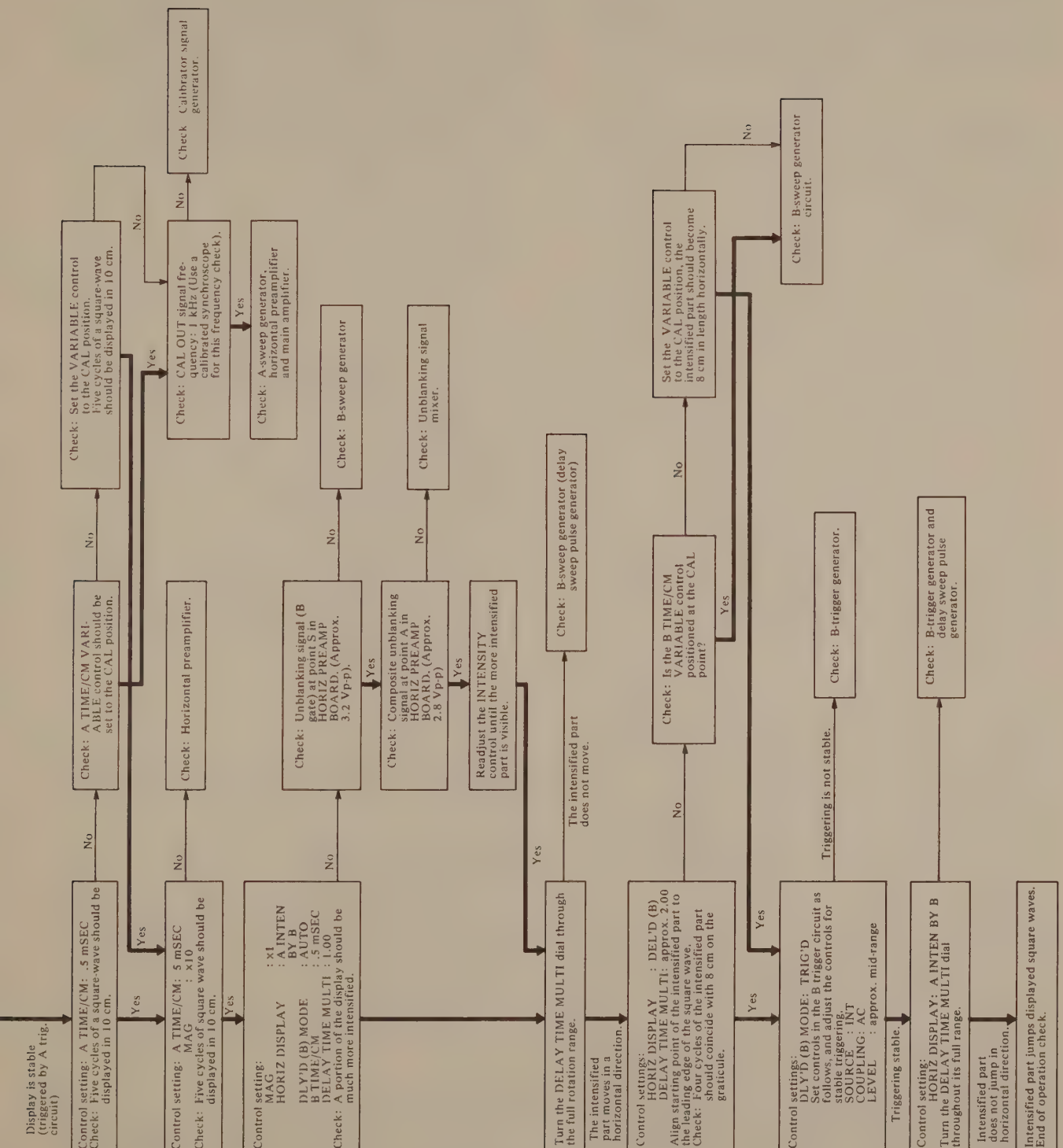
Replacement of Resistors and Capacitors

Specially selected passive elements, (resistors and capacitors), are used for the instrument, therefore defective parts should be replaced with suitable spares.

Burnt resistors or shorted capacitors may result from short-circuiting or serious deterioration of transistors or diodes. Check the cause of the trouble and replace any defective active elements as well as passive elements.

Table 5—6 Troubleshooting flow chart


Connect the instrument to the rated line voltage source, and turn the POWER switch on.
Pilot lamp does not light.
Check: Power cord, fuse, thermal cut-out relay, power switch, power transformer and pilot lamp.
Pilot lamp lights.
Check: Output voltage of low-voltage power supplies given in Table 7—1.
Voltage is incorrect
Check: Position of the LINE VOLTAGE RANGE selection switch and the line voltage.
No
Check and calibrate erroneous voltage regulator circuit.
Yes
Control setting: POSITION (vert. and horiz.) Mid-range
A TIME/CM : 1 mSEC
A SWEEP MODE : AUTO
HORIZ DISPLAY : A
INTENSITY : Turn clockwise gradually.
Trace is not obtained
Check: Push the TRACE FINDER switch and adjust the POSITION controls in CH 1, CH 2 and HORIZ circuits to position the trace in the center of the viewing area.
Release the TRACE FINDER switch.
Trace is unobtainable, but a spot appears.
Check: Observe sawtooth wave at test point N in the A SWEEP BOARD with another synchroscope. (Amplitude should be 9 Vp-p).
No
Check: A-sweep generator circuit.
Yes
Trace is obtainable.
Trace remains within display area
Check: Observe sweep output at point N in the HORIZ PREAMP BOARD. (amplitude: approx. 2 Vp-p)
No
Check: Horizontal preamplifier circuit.
Yes
Adjust the FOCUS and ASTIG controls for optimum focusing.
Focus unobtainable.
Check: CRT circuit
Check: Sawtooth wave output at horizontal deflection plate of CRT. (approx. 50 Vp-p, plate to chassis)
No
Check: Horizontal amplifier circuit.
Yes
Trace focused
Display moves in one channel only.
Check: Preamplifier circuit in the unadjustable channel.
Control setting: MODE: CHOP or ALT
Adjust POSITION controls in CH 1 and CH 2
Both channels are unadjustable.
Check: Vertical switching circuit and main amplifier circuits. If they are normal, check preamplifiers.
Check: Unblanking signal output (approx. 3 Vp-p) at point V in the HORIZ PREAMP BOARD.
No
Check: Unblanking gate signal (supplied to Z axis amplifier input).
Yes
Both traces move vertically.
Traces do not move.
Rotate the HORIZONTAL POSITION and FINE controls.
Check: Horizontal preamplifier and main amplifier.
Check: Unblanking signal output at Z AMP BOARD (input side of C809, approx. 80 Vp-p).
No
Check: Z axis amplifier circuit.
Yes
Trace move in horizontal direction.
Check: CRT circuit.
Connect the CAL OUT to inputs of CH 1 and CH 2.
Change control setting to;
AC-GND-DC : DC
VOLTS/CM : 0.1
CALIBRATOR VOLTS : 0.5
Check: Display amplitude should be approx. 5 cm in both channels.
No
Check: VOLTS/CM VARIABLE must be set to the CALIB position.
No
Check: Set the VARIABLE control to the CALIB position. The display amplitude should become approx. 5 cm.
Only one channel is defective.
Check: Preamplifier in the defective channel.
Both channels are defective.
Yes
Yes
Yes
Control settings: Turn the TRIGGER switch to the CH 1 position.
SOURCE : INT
COUPLING : AC
LEVEL : approx. mid-range
Adjust controls in the A TRIGGER circuit to obtain a stable display.
Stable triggering is unobtainable.
Control setting: TRIGGER switch to CH 2
Check: Triggering operation in CH 2.
No
Check: A TRIGGER generator and CH 2 trigger amplifier.
Yes
Check: CH 1 triggering amplifier.
Check: Output voltage of the CALIBRATOR OUT. (Use a calibrated synchroscope for this check.)
No
Check: Calibrator circuit.
Yes
Check: Vertical deflection circuits.


Display is stable (triggered by A trig. circuit)
Control setting: A TIME/CM: .5 mSEC
Check: Five cycles of a square-wave should be displayed in 10 cm.
No
Check: A TIME/CM VARIABLE control should be set to the CAL position.
No
Check: Set the VARIABLE control to the CAL position. Five cycles of a square-wave should be displayed in 10 cm.
No
Check Calibrator signal generator.
Yes
Yes
Yes
Control setting: A TIME/CM: 5 mSEC
MAG : x10
Check: Five cycles of square wave should be displayed in 10 cm.
No
Check: Horizontal preamplifier.
Check: CAL OUT signal frequency: 1 kHz (Use a calibrated synchroscope for this frequency check).
No
Yes
Check: A-sweep generator, horizontal preamplifier and main amplifier.
Yes
Control setting:
MAG : x1
HORIZ DISPLAY : A INTEN BY B
DLY'D (B) MODE : AUTO
B TIME/CM : .5 mSEC
DELAY TIME MULTI : 1.00
Check: A portion of the display should be much more intensified.
No
Check: Unblanking signal (B gate) at point S in HORIZ PREAMP BOARD. (Approx. 3.2 Vp-p).
No
Check: B-sweep generator
Yes
Check: Composite unblanking signal at point A in HORIZ PREAMP BOARD. (Approx. 2.8 Vp-p)
No
Check: Unblanking signal mixer.
Yes
Readjust the INTENSITY control until the more intensified part is visible.
Yes
Turn the DELAY TIME MULTI dial through the full rotation range.
The intensified part does not move.
Check: B-sweep generator (delay sweep pulse generator)
The intensified part moves in a horizontal direction.
Control settings:
HORIZ DISPLAY : DEL'D (B)
DELAY TIME MULTI: approx. 2.00
Align starting point of the intensified part to the leading edge of the square wave.
Check: Four cycles of the intensified part should coincide with 8 cm on the graticule.
No
Check: Is the B TIME/CM VARIABLE control positioned at the CAL point?
No
Set the VARIABLE control to the CAL position, the intensified part should become 8 cm in length horizontally.
No
Check: B-sweep generator circuit.
Yes
Yes
Control settings:
DLY'D (B) MODE: TRIG'D
Set controls in the B trigger circuit as follows, and adjust the controls for stable triggering.
SOURCE : INT
COUPLING: AC
LEVEL : approx. mid-range
Triggering is not stable.
Check: B-trigger generator.
Triggering stable.
Control setting:
HORIZ DISPLAY: A INTEN BY B
Turn the DELAY TIME MULTI dial throughout its full range.
Check: B-trigger generator and delay sweep pulse generator.
Intensified part does not jump in horizontal direction.
Intensified part jumps displayed square waves.
End of operation check.

Fuse Replacement

The power line fuse is located on the rear panel, and power supply fuses are collectively mounted on the right side (refer to Figure 7-5) of the instrument.

Details of fuses are shown in Table 5-8.

Table 5–8 Fuses

Circuit Symbol	Fuse type	Function	Location of Fuse Holder
F1002	3A slowblow	For AC 100 V operation	Rear panel
	1.5 A slowblow	For AC 200 V operation	Rear panel
F1000	0.5 A quick acting	+150 V line	Right rear of instrument
F1001	1 A quick acting	+75 V line	Right rear of instrument
F 900	1 A quick acting	CRT line	Right side of instrument

Removal of Circuit Boards

The printed circuit boards can be removed by disconnecting the wires to the board and removing the mounting screws.

The external connections to the board must be properly soldered to the board after replacement in order to avoid damage to transistors and/or resistors.

CRT Replacement

Handle the CRT with extreme care as excessive force or shock may cause it to break or crack. If the deflection plate pins or electrode pins are bent, it may cause the glass sealant around the pins to crack.

Remove the CRT in the following sequence.

(1) Remove both side panels and the rear panel.
(2) Unsolder the wire leads from the rotation and other coils of the CRT.
(3) Remove the connectors from the deflection plate pins on the neck of CRT and the anode cap on the left front side of the CRT.
(4) Remove the CRT socket.
(5) Remove the two horizontal mounting screws on the neck of the CRT.
(6) Remove the four screws which secure the bezel to the front panel, and remove the bezel and filter.

Then, pull the CRT out the front side of the instrument.

Reinstall the CRT in the reverse sequence. Be sure the deflection plate connectors are correct. Pattern distortion correction, XY axes alignment, and deflection sensitivity differ with individual CRT's. These items must be calibrated after replacement of the CRT. (For calibration of these items, refer to Chapter 7, "Pattern Distortion Correction, XY Axes alignment, or Deflection Sensitivity.")

Replacement of High-Voltage Transformer

Prior to replacing the high-voltage oscillator transformer which supplies high voltages to the CRT circuit, be sure to disconnect the power cord from the line. Be careful when handling the high-voltage circuit, since high voltages may remain charged in capacitors.

Follow the replacement procedures given below .

(1) Remove the left and right covers.
(2) Loosen the four mounting screws on the high-voltage circuit cover marked CRT CIRCUIT (OSCILLATOR), and remove the cover.
(3) Pull out the horizontal axis plug-in unit. The unit is screw mounted to the main chassis at the rear or bottom of the unit.
(4) Remove the anode cap from the acceleration anode located on the left front of the CRT. Loosen the anode cap cable. Discharge the high-voltage which may remain in the anode circuit before removing the cap.
(5) Pull out the high-voltage circuit containing the high-voltage transformer and a white acrylic resin box. The high-voltage circuit can be removed by loosening the seven mounting screws from the space for the horizontal axis plug-in unit.
(6) Detach the high-voltage transformer from the white box.
(The transformer is screw-mounted to the rear panel of the high-voltage chassis.)
(7) Remove the rubber band (coated with vinyl tube) from the transformer.
(8) Unsolder terminal connections, and remove the transformer. The high-voltage transformer can be mounted in the reverse sequence. When the transformer is replaced, the high-voltage circuit must be calibrated. Refer to "High Voltage Circuit" in Chapter 7 for the calibration procedures.

Replacement of Rotary Switch

Rotary switches are mounted on the vertical or horizontal axis plug-in unit and the main panel. Before replacing switches mounted on a plug-in unit, pull out the unit.

The rotary switches are replaced in the following sequence.

(1) Remove knob (or knobs).
(2) Unsolder wiring to the switch. Ensure that no solder is dropped on the switch contacts. Remove wiring being careful not to damage the contacts. Do not deform or cut the wiring, as it may cause confusion when re-wiring.
(3) Loosen mounting nut to the panel and supporting bracket to chassis, if any.
Rotary switches can be mounted in the reverse steps.

Replacement of Lever Switches

The lever switches are mounted on the sub panel located behind the front panel. The front panel must be removed before replacing the lever switches.

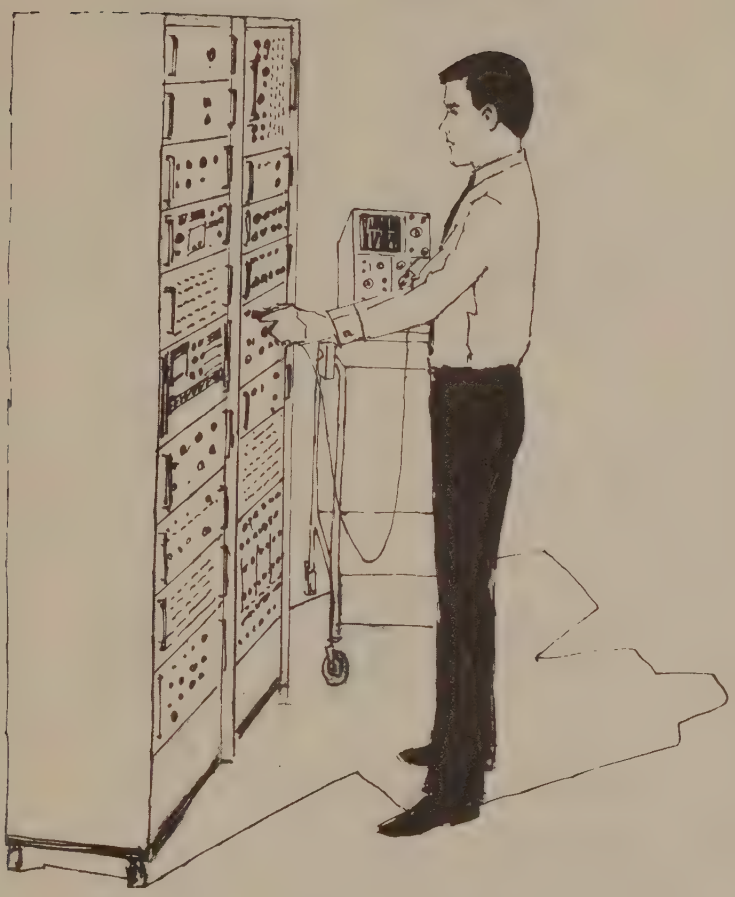
(1) Removal of front panel
Remove knobs from controls. Remove BNC connectors, GND terminals as these parts are secured through two panels.
(2) Unsolder wiring to the lever switches. Milky white wafers of lever switches (made of polyester cloth substrate epoxy resin laminates) are sensitive to heat during soldering. Use a soldering iron of less than 25 watts, and complete unsoldering quickly. Do not move contacts and terminals during the soldering, as it may result in defective contact.
(3) Remove the lever switch from the sub-panel.
The lever switches can be mounted in the reverse sequence.
Observe the precaution in step (2) above for soldering.

Replacement of Power Transistors

Power transistors are mounted to the chassis using a mica insulator between the transistor and the chassis. To improve the conduction of heat, apply a small amount of silicone grease to the mica sheet.

notes

CHAPTER 6 PERFORMANCE CHECK



This section of the manual gives performance check procedures for the Model SS–212. It is necessary to check performance of this instrument after a repair is made or the instrument has been used over a long period. Recalibration may be required to achieve proper performance of the instrument.

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▷ Performance Check

Performance check of the Model SS-212 can be conducted without removing covers or checking internal circuits, but by simply operating panel controls. If any malfunction is detected during this check, servicing and/or calibration as described in Chapter 7 of this manual is required.

▷ Test Instrument Required

Various test instruments are required for complete performance check of the Model SS-212.

Precautions on test instruments will be given below.

(1) BNC type connectors are used in the SS-212. If the output connector of test instrument is not the BNC type, a conversion plug for the BNC connector will be required for connection of the test cord.

(2) Characteristics and accuracy of test instrument should be equivalent to or better than those described herein. The instrument must be properly calibrated.

(3) When using signal generators, be sure to terminate the generator output with a matched tremination.

(4) Ordinarily, sine wave signal generators are calibrated for RMS value. Note that voltages in SS-212 indicate the peak-to-peak value. The RMS value of a sine wave signal is represented by the peak-to-peak value as shown below.

$$\text{Voltage (rms)} = \frac{\text{Voltage(Peak to Peak)}}{2\sqrt{2}}$$

1. DC Voltmeter [2]
   - Accuracy: 2%
   - Sensitivity: 20 K ohms/volt or more
   - Voltage range: 0 to 1,000 V, 2,500 V
2. Synchroscope Oscilloscope
   - Vertical deflection sensitivity: 5 mV/cm or more
   - Frequency bandwidth: DC to 50 MHz
3. Sine Wave Generator
   - Frequency: 10 Hz to 50 kHz
   - Output level: 1 mV to 7.75 V (rms)
   - Output level accuracy: 2% (must be calibrated better than 0.5% at 1 kHz)

   NOTE: For more accurate measurement, a resistive attenuator with maximum attenuation of 10 dB (0.1 dB step) must be used.
4. Signal Generator

   A sine wave signal generator known as the standard signal generator (SSG).

   For proper operation check of SS-212, oscillating frequency range of the signal generator must be extended from 50 kHz to 200 MHz or higher. Ordinarily, two generators will have to be used to cover the frequency range continuously. Normally, the lower range generator covers 50 kHz to 50 MHz, and the higher range generator covers 10 MHz to 480 MHz.

   Frequency range
   1. 50 kHz to 50 MHz
   2. 10 MHz to 200 MHz

   - Output level: 1 mV to 1 V rms
   - Output level accuracy: ±1 dB
5. Time Marker Generator
   - Marker output: 0.1 μsec to 5 sec
   - Accuracy: 0.1%
6. Square Wave Generator (I)
   - Rise time: less than 0.1 μsec
   - Output voltage: 5 mV to 50 V
   - Repetition frequency: 1 kHz
   - Waveform: must have low distortion
7. Square Wave Generator (II)
   - Rise time: 20 nsec or smaller
   - Output voltage: 0 to 1 V
   - Repetition frequency: 60 Hz, 1 kHz, 15 kHz, 100 kHz, 250 kHz and 1 MHz
   - Waveform: must have low distortion
8. Square Wave Generator (III)
   - Rise time: 500 psec or smaller
   - Output voltage: 0 to 1 V
   - Repetition frequency: Higher than 50 Hz
   - Waveform: must have low distortion
9. Auxiliary Parts
   - (a) Coaxial cable: 50 ohm
   - (b) 50 ohm termination (2 terminations)

     Used to terminate output of square wave or standard signal generator. For example, IWATSU's BB50M1 (BNC).
   - (c) BNC-T connector
   - (d) Signal divider

     A coaxial connector to branch high frequency signal. IWATSU's B-50D3 (BNC) or equivalent.
   - (e) Coaxial attenuator

     An attenuator to reduce output voltage of square wave generator. When the generator is provided with a calibrated output attenuator, the coaxial attenuator may not be required. IWATSU's AA series attenuator or equivalent.

▷ Preliminary Procedure for Performance Check

First check that the line voltage is correct and is suitable for your synchroscope, also check that the LINE VOLTAGE RANGE switch in the rear panel is set to the proper range.

Turn the power switch off and connect the power cord to the line. Set controls as given below.

Knobs in CRT circuit

FOCUS	Approx. mid-range
INTENSITY	Fully counterclockwise
SCALE ILLUM	Any position

Vertical plug-in unit (when the same control is present in both channels, position two controls as given below)

VOLTS/CM	10 mV
VARIABLE	CALIB
POSITION	Approx. mid-range
AC-GND-DC	DC
MODE	CH 1
TRIGGER	CH 1
CH2 POLARITY	NORM

Trigger controls (apply commonly to A and B)

LEVEL	Approx. mid-range
SLOPE	+
COUPLING	AC
SOURCE	INT

Sweep circuit knobs

DELAY TIME MULTI DIAL	1.00
A TIME/CM	1 msec
B TIME/CM	1 msec
A VARIABLE	CALIB
A SWEEP MODE	AUTO
DLY'D (B) MODE	AUTO
HORIZ DISPLAY	A
MAG	X1
POSITION	Approx. mid-range
POWER	OFF

Left side panel control

BAND WIDTH	50 MHz

Right side panel control

B TIME/CM VARIABLE	CALIB

After the controls are set to the indicated positions, turn the power switch on, and allow the instrument to warm up and stabilize for one hour. Ambient temperature should be +25°C ±5°C. Perform the operation check in the following sequence:

1. +15 V and -15 V Power Supply

REQUIREMENTS

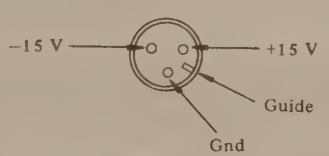
DC voltage across CH1 and CH2 PROBE POWER sockets on vertical plug-in unit and chassis (GND) must be +15 V and -15V, respectively.

OPERATION

(a) Set the DC voltmeter [2] to 15 V range, or the closest higher voltage range, and connect the meter across the PROBE POWER socket pin and GND terminal.
(b) Change polarity of voltmeter when measuring the -15 V.

CHECK

Check the voltages for CH1 and CH2, as shown below.



2. Horizontal Alignment of Trace

REQUIREMENT

Trace must be parallel to the horizontal scale.

OPERATION

(a) Turn the INTENSITY control until a trace appears on the viewing area.
(b) Turn the POSITION (VERT) control of CH1 and position the trace in the center of the viewing area.
(c) Adjust the FOCUS control for optimum focusing.

CHECK

(a) The trace must be parallel to the horizontal scale.
(b) If not, adjust the TRACE ROTATION control located on the right side panel.

3. Astigmatism

REQUIREMENT

The display must be sharply focused.

OPERATION

(a) Adjust the sine wave generator to 1 kHz, and feed the signal output to the CH1 INPUT. Adjust output control to set the amplitude of the displayed waveform to 60 mm.
(b) Trigger the display using the LEVEL a control.

CHECK

Adjust the FOCUS control. The display must be sharply focused throughout the viewing area. If not, it must be corrected by turning the ASTIG control.

4. Pattern Distortion

REQUIREMENT

A vertical line in the display must be straight to within 1 mm in the viewing area, and a horizontal line must be straight to within 0.9 mm in the area. (Refer to Figure 6-1)

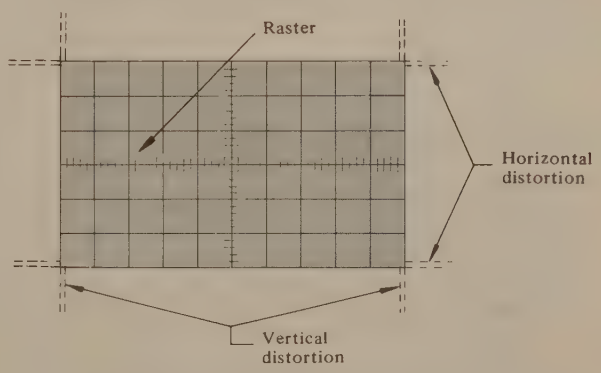
OPERATION

(a) Tune the sine wave generator to 20 kHz, and adjust output level so the display amplitude will be set to 60 mm.
(b) Adjust sweep controls so a raster will be displayed on the viewing area, and turn the horizontal POSITION control to align the beginning of the raster to the leftmost vertical scale.
(c) Readjust the horizontal POSITION control to align the end of the raster to the rightmost vertical scale.

CHECK

Vertical line of display in the fringe of 6 cm x 10 cm area must be straight within 1 mm and horizontal line of display must be straight within 0.9 mm in the same area.

Figure 6–1 Pattern Distortion



5. STEP ATTEN BAL (CH1 and CH2)

REQUIREMENT

Trace must not shift vertically when the VOLT/CM switch is changed from 5 mV to 10 mV.

OPERATION

Set the AC-GND-DC switch to the GND position, and adjust the vertical POSITION control to position the trace in the center of the viewing area.

CHECK

Check that the trace is held stable against changing of the switch position from 5 mV/cm to 10 mV/cm

6. CH1 and CH2 Sensitivity

REQUIREMENT

Display amplitude for an input signal of 40 mV with the VOLTS/CM switch set to the 10 mV position must be 40 mm ± 0.2 mm.

OPERATION

Change the control setting as shown below.

(a) VOLTS/CM 10 mV
VARIABLE CAL
AC-GND-DC DC
MODE A channel to be checked.

(b) Set output level of a sine wave generator to 40 mV p-p at 1 kHz, and supply the signal to the CH1 (or CH2) INPUT.

CHECK

Measure vertical amplitude of display. The amplitude must be 40 mm ± 0.2 mm

7. ADDED Operation

REQUIREMENT

A sum of two input signals must be displayed.

OPERATION

(a) Set the sine wave generator output to 25 mV p-p and feed the signal to CH1 and CH2 inputs simultaneously.
(b) Set the MODE switch to the ADDED position.

CHECK

Display amplitude must be 50 mm p-p. (±3%)

8. CH1 and CH2 Deflection Sensitivity

REQUIREMENT

Accuracy of vertical deflection sensitivity must be within ±3% of the VOLTS/CM switch indication.

OPERATION

(a) Change the MODE switch to the CH1 position.
(b) Set the AC-GND-DC switch of CH2 to the GND position.
(c) Confirm that the VARIABLE controls (in CH1 and CH2) are correctly set to the CALIB position.

CHECK

(a) Check deflection sensitivity of the VOLT/CM switch in CH1 at each step. Input signal level, required display amplitude and allowance for each switch range are given in Table 6-1.
(b) Repeat the same check for CH2.

Table 6–1 Vertical Deflection Sensitivity

VOLTS/CM switch position	Sine wave generator output (at 1 kHz)	Vertical display amplitude (mm)	Allowance (max. 3 %)
5 mV	20 mVp-p	40	±0.2 mm only in these two ranges. (accuracy ±0.5%)
10 mV	40 mVp-p	40	
20 mV	0.1 Vp-p	50	±1.5 mm
50 mV	0.2 Vp-p	40	±1.2 mm
.1 V	0.5 Vp-p	50	±1.5 mm
.2 V	1 Vp-p	50	±1.5 mm
.5 V	2 Vp-p	40	±1.2 mm
1 V	5 Vp-p	50	±1.5 mm
2 V	10 Vp-p	50	±1.5 mm
5 V	20 Vp-p	40	±1.2 mm

9. VARIABLE (CH1 and CH2) Range

REQUIREMENT

When the VARIABLE control is turned from the CALIB position (cw) to extreme left position (ccw), the deflection sensitivity must be changed continuously.

OPERATION

(a) Change the MODE switch to the CH1 position.
(b) Set the VOLTS/CM switch to the 10 mV position.
(c) Set the AC-GND-DC switch to the AC position.
(d) Set the sine wave generator output to 50 mV p-p, and connect to the CH1 input.

CHECK

(a) The display amplitude should decrease continuously until it is reduced to 20 mm or less at the leftmost position (ccw) of the control. The UNCAL lamp should light when the control is not set to the CALIB position.
(b) Change the MODE switch to CH2, and repeat the same check for CH2.

10. CH2 POLARITY

REQUIREMENT

Polarity of display must be reversed when the CH2 POLARITY switch is changed from NORM to INVERT.

OPERATION
(a) Set the VARIABLE controls in CH1 and CH2 to the CALIB position.
(b) Set the sine wave signal generator output level to 20 mV p-p and connect to the CH1 and CH2 inputs simultaneously.
(c) Change the MODE switch to the ADDED position.

CHECK
(a) Set the CH2 POLARITY switch to the NORM position. Display amplitude must be approx. 40 mm.
(b) Change the CH2 POLARITY switch to the INVERT position. Display amplitude must be zero or quite closs to zero.

ADDITIONAL OPERATION
Return the CH2 POLARITY switch to the NORM position, and remove signal from CH1 and CH2 inputs after the check is completed.

11. AC-GND-DC Operation

REQUIREMENT
Coupling mode of input signal must change correctly as indicated by the switch positions.

OPERATION
(a) Set the MODE and the AC-GND-DC (CH1) switches to the CH1 and DC position respectively.
(b) Set the CALIBRATOR switch to the 20 mV position and connect the CAL OUT to the CH1 INPUT.
(c) Position the displayed square wave so the bottom of the display is aligned with the center horizontal scale.
(d) Change the AC-GND-DC switch to the GND position.
(e) Change the switch to the AC position.

CHECK
(a) When the switch is set to the GND position (in step d above) only a horizontal line should remain on the viewing area.
(b) When the switch is set to the AC position (in step e above) square wave signals should be displayed again. In this case, the signal should be displayed symmetric to the center horizontal scale.
(c) Change the MODE switch to the CH2 position, and repeat the same check for CH2.

12. CH2 OUT Sensitivity (In Cascade Connection)

REQUIREMENT
When CH2 is connected in cascade to CH1, the deflection sensitivity must increase to 1 mV/cm.

OPERATION
(a) Set the VOLTS/CM switches in CH1 and CH2 to the 5 mV position, and the VARIABLE control to the CALIB position.
(b) Set the AC-GND-DC switches (in CH1 and CH2) to the DC position.
(c) Set the MODE switch to the CH1 position.
(d) Connect the CH2 OUT and CH1 INPUT through a coaxial cable.
(e) Set the sine wave signal generator to 1 kHz, and its output level to 4 mV p-p. Connect the signal to the CH2 INPUT.

CHECK
Amplitude of display must be 40 mm ±3%.

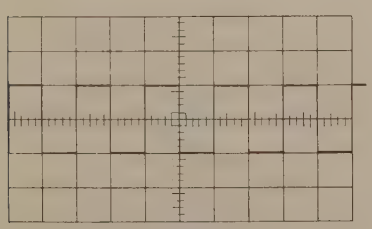
ADDITIONAL OPERATION
Remove the input signal from input connector.

13. Vertical Linearity in Low Frequency (CH1, CH2)

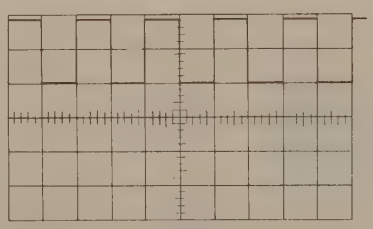
REQUIREMENT
Vertical amplitude of a display, 20 mm when positioned at the center of the graticule must not vary more than 0.4 mm when the upper or lower ends of signals are shifted to the top or bottom horizontal scale.

OPERATION
(a) Set the VOLTS/CM switches (CH1, CH2) to the 20 mV position.
(b) Set the CALIBRATOR VOLTS switch to the 50 mV position.
(c) Connect the CAL OUT and CH1 INPUT through a coaxial cable.

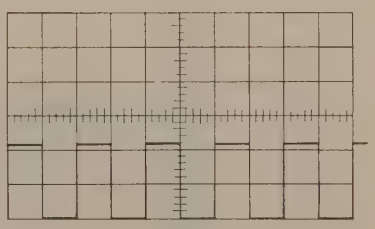
Figure 6–2 Vertical Linearity in Low Frequency



Correct deflection at center of graticule



Compression



Expansion

(d) Set the A and B TIME/CM switch to .5 mSEC and trigger the display. Position the display correctly in the center of the viewing area, and adjust VARIABLE (CH1, CH2) to set the display amplitude correctly to 20 mm.
(e) Move the displayed waveform vertically by 20 mm up and down.

CHECK
(a) When the displayed waveform is shifted by 20 mm, amplitude of the displayed signal must not vary more than 0.4 mm.
(b) Repeat the same check for CH2.

ADDITIONAL OPERATION
Remove connection between CAL OUT and INPUT.

14. ALT (Alternate) Operation

REQUIREMENT
Alternate display of signals must be possible in all sweep time ranges.

OPERATION
(a) Set the MODE switch to the ALT position.
(b) Position the two traces 2 cm apart.
(c) Change the A TIME/CM switch setting throughout the full range.

CHECK
Two traces, CH1 and CH2, must be alternately swept. In higher sweep time ranges both of the traces will be visible simultaneously.

15. CHOP Operation

REQUIREMENT
Two traces must be chopped and displayed simultaneously.

OPERATION
Set the MODE switch to the CHOP position.

CHECK
Two traces must be present.

16. VOLTS/CM Attenuator Compensation (CH1 and CH2)

REQUIREMENT
Distortion of displayed waveform must be within +1% or -2% in each VOLTS/CM switch range.

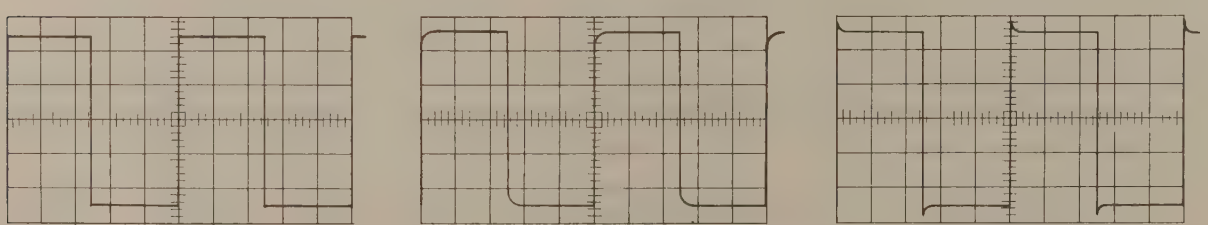
OPERATION
(a) Change control setting as shown below.

VOLTS/CM	5 mV
VARIABLE	CALIB
MODE	CH 1
AC-GND-DC	DC
A TIME/CM	.2 mSEC

(b) Connect the probe (attenuation ratio 10 : 1) to the CH1 INPUT.
(c) Connect the probe to output of squarewave generator [I]. Set the generator to 1 kHz and 250 mV output level.
(d) Amplitude of display should be approx. 50 mm

CHECK
(a) Check that no overshoot or rounding is present in the displayed square wave. If it is present, adjust the compensation capacitor in the probe. (Refer to Figure 6-3)
(b) Change the VOLT/CM switch sequentially from 10 mV to the 5 V range, and check the displayed waveform. Adjust the generator output so amplitude of display will be retained at approx. 50 mm in each VOLTS/CM switch range. In higher voltage ranges, the signal generator output level may become insufficient to retain the rated display amplitude, 50 mm.
(c) Repeat the same check for CH2.

Figure 6–3 VOLTS/CM Attenuator Compensation with Capacitor in the Probe



17. Square Wave Response of VOLTS/CM in 5 mV and 10 mV Ranges

REQUIREMENT

Distortion in square wave displayed at the center of viewing area with an amplitude of 40 mm must be within the following ranges, at deflection sensitivities of 5 mV/cm and 10 mV/cm

Overshoot	5%
Undershoot	3%
Ringing	5%
Sag (at 1 MHz)	1%
Sag (at 60 Hz)	1%

OPERATION - 1

(a) Change the control setting as shown below.

BAND WIDTH	FULL
VOLTS/CM	10 mV
MODE	CH 1
AC-GND-DC	DC
A TIME/CM	50 nSEC

(b) Connect the CH1 INPUT to square wave generator (III) which is terminated by a proper 50 ohms termination (for example, BB-50M1).

When the output voltage of the signal generator is too large, the output must be attenuated by using an attenuator having good high-frequency characteristics (for example, Iwatsu AA series).

(c) Adjust deflection sensitivity so the signal will be displayed 40 mm in amplitude and positioned at the center of the viewing area.

Adjust the generator frequency to display only one complete pulse. The leading edge of the pulse must be clearly visible.

CHECK - 1

(a) Check that distortion in waveform is smaller than the following limits.

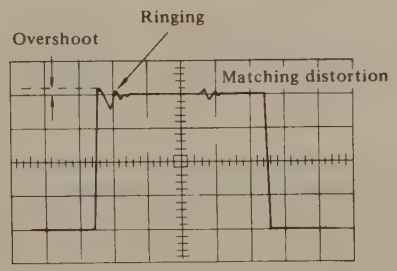
Overshoot	5%
Undershoot	3%
Ringing	5%

(b) Repeat the same check for 5 mV range (CH1).

(c) Repeat the same check for 10 mV and 5 mV ranges in CH2.

(d) Example of distortion in pulse waveform is shown in Figure 6-4.

Figure 6–4 Square Wave Characteristics



OPERATION - 2

(a) Change the control settings as shown below.

VOLTS/CM	10 mV
MODE	CH 1
A TIME/CM	0.5 μs

(b) Set the square wave generator (II) to 1 MHz, and properly terminate the output before connecting it to the CH1 INPUT.

(c) Set the display amplitude to 40 mm, and position it in the center of the viewing area.

(d) Change the A TIME/CM switch to the 10 mSEC range and change the frequency of generator (II) to 60 Hz.

CHECK - 2

Sag in the displayed square wave must be within 1% at 1 MHz and 60 Hz.

18. Vertical Amplifier Bandwidth

REQUIREMENT

Bandwidth of the vertical amplifier is within -3 dB at 100 MHz in the 5 mV/cm range, -3 dB at 200 MHz in the 10 mV/cm range, and -4 dB at 200 MHz in the ranges between 20 mV/cm and 5 V/cm

When the BAND WIDTH switch is changed to the 50 MHz range, the frequency bandwidth is reduced to 50 MHz and frequency response variations are kept within -3 dB throughout the range.

OPERATION - 1

(a) Set controls as shown below.

VOLTS/CM	10 mV
MODE	CH 1
A TIME/CM	1 mSEC

(b) Feed a signal that output is terminated, to the CH1 INPUT.

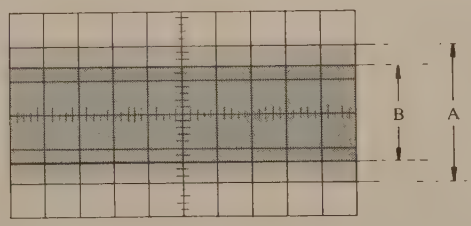
(c) Set the signal generator frequency to 10 MHz, and adjust display amplitude to 40 mm by changing the generator output. The generator output level must be retained at this level when signal frequency is changed.

(d) Change the generator frequency to 200 MHz, and read the display amplitude.

CHECK - 1

(a) In the 10 mV range, display amplitude at 200 MHz

Figure 6–5 Bandwidth



must be 28 mm or more. In ranges between 20 mV and 5V, the amplitude at 200 MHz must be greater than 25 mm (reference amplitude 40 mm, at 10 MHz). Check operation for these ranges in a manner identical to that for the 10 mV range.
(b) Change the VOLTS/CM switch to the 5 mV position, and set the generator frequency to 100 MHz. Display amplitude must be 28 mm or more.
(c) Check the frequency characteristics of CH2 at 5 mV, 10 mV and 20 mV to 5 V ranges. (Reffer to in the case of CH1)

OPERATION - 2
Set the BAND WIDTH switch to the 50 MHz range and read a signal amplitude displayed on the graticule, following the same operation as described in Operation - 1.

CHECK - 2
Ensure that the signal amplitude on the graticule is more than 28 mm, with the BAND WIDTH switch set at 50 MHz, and VOLT/CM switch at the 10 mV ranges. Similarly, the amplitude should be more than 28 mm, at 20 mV to 5 V or 5 mV ranges.

ADDITIONAL OPERATION
Change the BAND WIDTH switch to the FULL range.

19. CH2 OUT (Cascade Connection) Bandwidth

REQUIREMENT
Bandwidth of cascade connected amplifiers must be within -3 dB at 50 MHz.

OPERATION
(a) Connect the CH2 OUTPUT to the CH1 INPUT through a 50 ohm coaxial cable.
(b) Set the MODE switch to the CH1 position.
(c) Connect the signal generator output to the CH2 INPUT through a terminator.
(d) Set the signal generator frequency to 100 kHz and hold display amplitude to 40 mm by changing the generator output level. The output level of the signal generator must remain fixed when signal frequency is changed.
(e) Change the signal generator frequency to 50 MHz, and read amplitude of display.

CHECK
The display amplitude at 50 MHz must be greater than 28 mm.

20. CH2 OUT DC Level

REQUIREMENT
The DC level of CH2 OUT must be zero ±15 mV.

OPERATION
(a) Change the control settings as shown below.

VOLTS/CM (CH 1 and CH 2)	5 mV
AC-GND-DC (CH 1 and CH 2)	GND
MODE	CH2

(b) Connect the CH2 OUT to the CH1 INPUT through a 50 ohm coaxial cable.
(c) Position the trace in the center of the viewing area by turning the CH2 POSITION control.
(d) Set the MODE switch to the CH1 position.
(e) Position the trace on the center line of the graticule by turning the CH1 POSITION control.
(f) Change the CH1 AC-GND-DC switch to the DC position.

CHECK
The trace must remain in the viewing area (0 V ± 15 mV).

ADDITIONAL OPERATION
After the check is completed remove the connection between CH2 OUT and CH1 INPUT.

21. TRACE FINDER (Vertical Direction)

REQUIREMENT
Traces of CH1 and CH2 must be within the viewing area for the full rotation of the vertical POSITION control when the TRACE FINDER button is depressed.

OPERATION
(a) Set the AC-GND-DC CH1, CH2 switches to the GND and the MODE switch to the ALT position.
(b) Hold the TRACE FINDER button pushed down.
(c) Turn the CH1 and CH2 POSITION controls to their full rotation.

CHECK
Both the CH1 and CH2 traces must be retained within the viewing area.

22. Common Mode Rejection Ratio

REQUIREMENT
The common mode rejection ratio at 10 MHz must be larger than 20 :1.

OPERATION
(a) Change the control settings as shown below

VOLTS/CM (CH 1 and CH 2)	10 mV
POSITION (CH 1 and CH 2)	mid-range
AC-GND-DC (CH 1 and CH 2)	DC
A TIME/CM	1 mSEC

(b) Set the signal generator frequency to 10 MHz, branch the output signal by using a signal divider (IWATSU B-50D3 or equivalent), and terminate the branched signals. Feed the terminated signals to CH1 and CH2 inputs. Adjust the signal generator output level so the signal (displayed) will be 60 mm in either CH1 or CH2. (NOTE: The signal will be attenuated by 6 dB (±1 dB) in the signal divider B-50D3).
(c) Change the MODE and CH2 POLARITY switches to the ADDED and INVERT position respectively.

CHECK
Amplitude of the display must be reduced to 3 mm or less when the CH2 POLARITY is reversed.

23. Triggering Level

REQUIREMENT
A sine wave of 1 kHz must be continuously triggered

when the triggering level is changed within the range of 5 to 95% of the sine wave slope. Zero level of a signal must be triggered when the LEVEL control is set to approximately mid-range.

OPERATION - 1

(a) Change the control settings as shown below.

MODE	CH 1
CH 2 POLARITY	NORM
VOLTS/CM (CH 1 and CH 2)	10 mV
AC-GND-DC (CH 1 and CH 2)	AC
LEVEL (A and B)	0
TIME/CM (A and B)	.5 mSEC

(b) Set the sine wave signal generator to 1 kHz, feed the signal output to the CH1 input, and adjust the generator output to set the displayed amplitude to 5 mm.

(c) Turn the LEVEL (A) control gradually until the display is firmly triggered.

CHECK - 1

When the display is triggered, the LEVEL (A) control must be near the mid-range position.

OPERATION - 2

(a) Set the HORIZ DISPLAY to the DLY'D(B) position.

(b) Change the DLY'D(B) MODE to the TRIG'D position.

(c) Turn the LEVEL (B) control gradually until the display is firmly triggered.

CHECK - 2

The LEVEL (B) control must be near the mid-position.

OPERATION - 3

(a) Increase the output of the sine wave generator until the display amplitude reaches 60 mm

(b) Turn the LEVEL (B) control gradually around the zero point.

CHECK - 3

Starting point of stable triggering must move continuously between 5% and 95% of the sine wave slope.

OPERATION - 4

(a) Set the HORIZ DISPLAY to the A position.

(b) Turn the LEVEL (A) control gradually around the zero point (mid-position).

CHECK - 4

Starting point of stable triggering must move continuously between 5% and 95% of the sine wave slope.

24. A Triggering in High Frequency

REQUIREMENT

The A triggering circuit must be properly triggered, in both the internal and external modes, at the trigger levels shown in table 6-2.

OPERATION - 1

(a) Branch the signal generator output by a signal divider (IWATSU's B-50D3 or its equivalent) and terminate the branched outputs. Connect the signal to the CH1 (or CH2) INPUT and TRIG INPUT. Adjust the generator so that the signal level at the TRIG INPUT is 25 mV p-p. Set the generator frequency to 15 MHz

NOTE: The signal divider B-50D3 attenuates the generator output by 6 dB (±1 dB). Therefore, the signal from the divider is smaller than that of signal generator.

(b) Adjust the VOLTS/CM (CH1 and CH2) and VARIABLE controls to set the display amplitude to 2 mm.

(c) Change the TIME/CM switch to the 50 nSEC range.

(d) Set the SOURCE (A) switch to the INT position.

(e) Change the COUPLING (A) switch to the AC, LF REJ and DC position sequentially.

(f) Adjust the LEVEL (A) to trigger the display firmly.

CHECK - 1

Display must be stable on the viewing area in every position of switches (AC, LF REJ, DC).

OPERATION - 2

(a) Change the SOURCE (A) switch to the EXT position.

(b) Repeat steps (e) and (f) in Operation - 1 above.

CHECK - 2

Repeat Check - 1.

OPERATION - 3

(a) Set the signal generator to 50 MHz, and adjust the output level of the generator to set the signal level at TRIGGER INPUT to 100 mV p-p.

(b) Adjust the VOLT/CM (CH1, CH2) switches and VARIABLE controls to set the display amplitude to 10 mm.

(c) Change the SOURCE (A) to the INT position.

(d) Repeat step (e) in Operation - 1.

(e) Adjust the LEVEL (A) and HF STAB controls to trigger the display firmly.

CHECK - 3

Repeat Check - 1.

OPERATION - 4

(a) Change the SOURCE (A) switch to the EXT position.

(b) Repeat (e) in Operation - 1.

(c) Repeat step (e) in Operation - 3.

CHECK - 4

Repeat Check - 1.

OPERATION - 5

(a) Set the generator frequency to 100 MHz, and adjust the output level to set the signal level at the TRIGGER INPUT to 150 mV p-p.

(d) Adjust the VOLTS/CM (CH1 and CH2) switches and VARIABLE controls to set the display amplitude to 30 mm.

(c) Change the A TIME/CM switch to 20 nSEC, and MAG knob to X10.

(d) Change the SOURCE (A) switch to the INT position.

(e) Repeat step (e) in Operation - 1.

(f) Repeat step (e) in Operation - 3.

CHECK - 5

Repeat the steps in Check - 1.

OPERATION - 6

(a) Change the SOURCE switch to EXT.

(b) Repeat step (e) in Operation - 1.
(c) Repeat step (e) in Operation - 3.

CHECK - 6
Repeat the steps in Check - 1.

OPERATION - 7
(a) Adjust the signal generator output level to set the signal level at the TRIG INPUT to 25 mV p-p.
(b) Adjust the VOLTS/CM (CH1 and CH2) and VARIABLE controls to set the display amplitude to 5 mm.
(c) Change the A SWEEP MODE switch to the HF position.
(d) Change the SOURCE (A) switch to the INT position.
(e) Repeat step (e) in Operation - 1.
(f) Repeat step (e) in Operation - 3.

CHECK - 7
Repeat the in Check - 1.

OPERATION - 8
(a) Change the SOURCE (A) switch to the EXT position.
(b) Repeat step (e) in Operation - 1.
(c) Repeat step (e) in Operation - 3.

CHECK - 8
Repeat the steps in Check - 1.

OPERATION - 9
(a) Change the signal generator frequency to 150 MHz, and adjust the output signal level to set the signal level at TRIG INPUT to 40 mV p-p.
(b) Adjust the VOLTS/CM (CH1 and CH2) to set the display amplitude to 30 mm p-p.
(c) Change the SOURCE (A) switch to the INT position.
(d) Repeat step (e) in Operation - 1.
(e) Repeat step (e) in Operation - 3.

CHECK - 9
Repeat the steps in Check - 1.

OPERATION - 10
(a) Change the SOURCE (A) switch to the EXT position.
(b) Repeat step (e) in Operation - 1.
(c) Repeat step (e) in Operation - 3.

CHECK - 10
Repeat the steps in Check - 1.

OPERATION - 11
(a) Set the signal frequency of the generator to 200 MHz, and adjust the output level to set the signal level at the TRIG INPUT to 70 mV p-p.
(b) Repeat step (e) in Operation - 1.
(c) Repeat step (e) in Operation - 3.

CHECK - 11
Repeat the steps in Check - 1.

25. A Triggering in Low Frequency

REQUIREMENT
At positions AC, HF REJ and DC of the COUPLING (A) switch, and when the triggering signal is 60 Hz, the display must be properly triggered with a display amplitude of 2 mm and it must be triggered when an external trigger signal, 25 mV in amplitude, is supplied.

OPERATION - 1
(a) Set the sine wave signal generator frequency, to 60 Hz, and adjust the output level to supply an external trigger signal of 25 mV in amplitude to the TRIG INPUT.
(b) Simultaneously, feed the signal generator output to the CH1 (or CH2) INPUT, and adjust the VOLTS/CM switch and VARIABLE control to set the display amplitude to 2 mm.
(c) Set the A TIME/CM switch to 10 mSEC.
(d) Set the MAG switch to the X1 position.
(e) Change the A SWEEP MODE to the AUTO position.
(f) Set the SOURCE (A) switch to the INT position.
(g) Change the COUPLING (A) switch to AC, HF REJ and DC, sequentially. If triggering of display is lost in any position of this switch, readjust the LEVEL (A) control.

Table 6–2 A trigger level in high frequency

SWEEP MODE	COUPLING	Frequency	Trigger level	
			Display amplitude for internal triggering	External trigger input level
AUTO	AC	15 MHz 50 MHz 100 MHz	2 mm 10 mm 30 mm	25 mVp-p 100 mVp-p 150 mVp-p
	LF REJ	15 MHz 50 MHz 100 MHz	2 mm 10 mm 30 mm	25 mVp-p 100 mVp-p 150 mVp-p
	DC	15 MHz 50 MHz 100 MHz	2 mm 10 mm 30 mm	25 mVp-p 100 mVp-p 150 mVp-p
HF	AC LF REJ DC	100 MHz 150 MHz 200 MHz	5 mm 30 mm —	25 mVp-p 40 mVp-p 70 mVp-p

CHECK - 1
Display must be firmly triggered in step (g) above.

OPERATION - 2
(a) Change the SOURCE (A) switch to the EXT position.
(b) Repeat step (g) in Operation - 1.

CHECK - 2
Repeat Check - 1.

26. A Triggering in LF REJ and HF REJ

REQUIREMENT
In the LF REJ mode, a 30 kHz signal must trigger the sweep, but a 60 Hz signal must not.
In the HF REJ mode, a signal 50 kHz or lower must trigger the sweep, but a signal or 1 MHz must not.

OPERATION - 1
(a) Set the sine wave generator frequency to 30 kHz and adjust the output to set the signal level at the TRIG INPUT to 25 mV p-p.
(b) Simultaneously, feed the generator output to the CH1 INPUT, and adjust the VOLTS/CM switch and the VARIABLE control to set the display amplitude to 2 mm.
(c) A TIME/CM switch to the 50 μSEC.
(d) Change the COUPLING (A) to the LF REJ position.
(e) Switch the SOURCE (A) switch to the INT and EXT positions alternately.
(f) Adjust the LEVEL (A) control until stable triggering is obtained. The triggering point in the INT triggering may be different from the triggering point in the EXT triggering mode.
(g) Change the sine wave signal generator frequency to 60 Hz.
(h) Set the A TIME/CM switch to the 10 mSEC. position.
(i) Repeat steps (e) above.

CHECK - 1
The sweep must be triggered firmly at 30 kHz, and not be triggered at 60 Hz.

OPERATION - 2
(a) Remove the sine wave generator, and connect a high frequency signal generator to the INPUT. The high frequency signal generator must be terminated by a 50 ohm termination. Adjust the generator to 50 kHz.
(b) Change the A TIME/CM switch to the 20 μSEC position.
(c) Change the COUPLING (A) switch to the HF REJ position.
(d) Repeat step (e) in Operation - 1 above.
(e) Repeat step (f) in Operation - 1.
(f) Change the signal generator frequency to 1 MHz.
(g) Change the A TIME/CM switch to the 1 μSEC position.
(h) Repeat step (e) in Operation - 1.

CHECK - 2
The sweep must be triggered firmly at 50 kHz and not be triggered at 1 MHz.

27. B Triggering in High Frequency

CAUTION: In this section, operation check procedures for the AC position of the COUPLING (B) switch are described. The check procedures similarly apply to the switch positions LF REJ and DC.

REQUIREMENT
The B trigger circuit must operate properly with the triggering signal levels shown in Table 6-3.

Table 6—3 B trigger level in high frequency

Frequency	Trigger level	
	Display amplitude for internal triggering	External trigger signal level
15 MHz	10 mm	100 mVp-p
50 MHz	20 mm	200 mVp-p

OPERATION - 1
(a) Branch the signal generator output signal by a signal divider (IWATSU B-50D3 or equivalent), and terminate the branched output. Feed the divided signals to the vertical INPUT (CH1 or CH2) and the TRIG OR HORIZ INPUT.
Set the signal generator to 15 MHz and adjust the output signal level to set the signal at the TRIG OR HORIZ INPUT terminal to 100 mV p-p.
NOTE: The signal divider attenuated the signal level by 6 dB (±1 dB).
(b) Adjust the VOLTS/CM (CH1 or CH2) switch and the VARIABLE control to set the display amplitude to 10 mm.
(c) Change the TIME/CM switches in A and B trigger circuits to the 50 nSEC position.
(d) Change the SOURCE (A) and (B) switches to the INT position.
(e) Change the COUPLING switches (A) and (B) to the AC position.
(f) Set the HORIZ DISPLAY switch to the A INTEN BY B position.
(g) Set the A SWEEP MODE switch to the AUTO position.
(h) Adjust the LEVEL (A) control until stable triggering is obtained.
(i) Change the DLY'D (B) MODE switch to the TRIG'D position.
(j) Adjust the LEVEL (B) control until the intensified part on the display is firmly triggered.

CHECK - 1
The intensified part on the display must be firmly triggered.

OPERATION - 2
(a) Change the SOURCE (B) switch to the EXT position.
(b) Repeat step (j) in Operation - 1.

CHECK - 2
Repeat Check - 1.

OPERATION - 3
(a) Change the signal generator frequency to 50 MHz and set the signal level at the TRIG INPUT to 200 mV p-p.
(b) Adjust the VOLTS/CM switches (CH1 and CH2) and VARIABLE controls to set the display amplitude to 20 mm
(c) Change the A and B TIME/CM switches to the 20 nSEC range.
(d) Change the SOURCE (B) switch to the INT position.
(e) Repeat step (j) in Operation - 1.

CHECK - 3
Repeat the steps in Check - 1.

OPERATION - 4
(a) Change the SOURCE (B) switch to the EXT position.
(b) Repeat step (j) in Operation - 1.

CHECK - 4
Repeat the steps in Check - 1.

28. B Triggering in Low Frequency

CAUTION: In this section, operation check procedures for the AC position of the COUPLING (B) switch are described. The procedures also apply to other switch positions, HF REJ and DC.

REQUIREMENT
The sweep circuit must be properly triggered at 60 Hz with a display amplitude of 10 mm in the internal triggering and with an external triggering signal of 100 mV p-p in the external triggering mode.

OPERATION - 1
(a) Set the sine wave signal generator frequency to 60 Hz and adjust the output level to set the external triggering signal at the TRIG INPUT to 100 mV p-p.
(b) Simultaneously supply the generator output to the vertical INPUT, and adjust the VOLTS/CM switch and the VARIABLE control to set the display amplitude to 10 mm
(c) Set the A and B TIME/CM switches to the 10 mSEC position.
(d) Adjust the SOURCE (B) switch to the INT position.
(e) Adjust the LEVEL (A) control for stable display.
(f) Adjust the LEVEL (B) control to trigger the intensified part on the display.

CHECK 1
The intensified part must be firmly triggered.

OPERATION - 2
(a) Change the SOURCE (B) switch to the EXT position.
(b) Repeat step (f) in Operation - 1.

CHECK - 2
Repeat Check - 1.

29. B Triggering in LF REJ and HF REJ

REQUIREMENT
The sweep must be triggered at 30 kHz and not be triggered at 60 Hz in the LF REJ mode.
In the HF REJ mode, the sweep must be triggered at 50 kHz and must not be triggered at 1 MHz.

OPERATION - 1
(a) Set the sine wave generator frequency to 30 kHz, and adjust the output level to set the external trigger signal at the TRIG OR HORIZ INPUT terminal to 100 mV p-p.
(b) Adjust the VOLTS/CM switch and the VARIABLE control to set the display amplitude to 10 mm.
(c) Set the A and B TIME/CM switch to the 50 μSEC.
(d) Change the COUPLING (B) switch to the LF REJ position.
(e) Switch the SOURCE (B) switch alternately to the INT and the EXT position.
(f) Adjust the LEVEL (B) control until stable triggering is obtained for the intensified part of the display. The triggering point for INT trigger may be different from the triggering point for the EXT mode.
(g) Change the sine wave generator frequency to 60 Hz.
(h) Change the A and B TIME/CM switches to the 10 mSEC range.
(i) Repeat step (e) above.

CHECK 1
The intensified part must be triggered firmly at 30 kHz, but not triggered at 60 Hz.

OPERATION - 2
(a) Replace the sine wave generator with a high frequency signal generator. Set the signal frequency to 50 kHz and terminate the signal output with a 50 ohm terminator.
(b) Set the A and B TIME/CM switches to the 20 μSEC position.
(c) Change the COUPLING (B) switch to the HF REJ position.
(d) Switch the SOURCE (B) switch alternately to the INT and the EXT positions.
(e) Adjust the LEVEL (B) control until the intensified part is firmly triggered on the display. The triggering point in the INT mode may be different from the triggering point in the EXT mode.
(f) Change the signal generator frequency to 1 MHz.
(g) Change the A and B TIME/CM switches to the 1 μSEC range.
(h) Adjust the LEVEL (B) control.

CHECK - 2
The intensified part must be triggered at 50 kHz but not be triggered at 1 MHz.

30. Single Sweep Operation

REQUIREMENT
The sweep must be actuated at the same A triggering level as that of the AUTO sweep operation, but the sweep circuit must stop until it is reset.

OPERATION
(a) Change the COUPLING (A and B) switches to the AC position.
(b) Set the A and B TIME/CM switches to the .5 mSEC position.
(c) Change the HORIZ DISPLAY switch to the A position.
(d) Change the A and B SOURCE switches to the INT position.
(e) Set the sine wave generator to 1 kHz, feed the signal to the CH1 or CH2 INPUT, and set the display amplitude to 10 mm
(f) Trigger the sweep by adjusting the LEVEL (A) control.
(g) Remove the signal cable from the INPUT.
(h) Change the A sweep MODE to the SINGLE position.
(i) Depress the RESET button.

CHECK
The lamp in the RESET button must light when the button is depressed.
The sweep must be actuated only once when the signal is supplied again. The lamp must go off with the sweep. Observation of the trace will be eased by turning the INTENSITY control clockwise.

31. SLOPE (A and B) Switches

REQUIREMENT
The sweep must be triggered correctly on the slope of the input signal as indicated by the SLOPE switch.

OPERATION - 1
(a) Change the A SWEEP MODE switch to the AUTO position.
(b) Set the sine wave generator frequency to 1 kHz, and the display amplitude to 40 mm
(c) Switch the SLOPE (A) switch alternately to the + and - positions.

CHECK - 1
At the + position of the SLOPE switch, the sweep must start from the positive going slope of the displayed waveform and at the - position, the sweep must start from the negative going slope.

OPERATION - 2
(a) Change the HORIZ DISPLAY switch to the DLY'D (B) position.
(b) Change the DLY'D (B) MODE switch to the TRG'D position.
(c) Switch the SLOPE (B) switch alternately to the + and - positions.

CHECK - 2
Repeat the steps in Check - 1.

32. Line Trigger Operation

REQUIREMENT
The sweep must be triggered at the line frequency.

OPERATION - 1
(a) Change the control settings as shown below.

HORIZ DISPLAY	A
A SWEEP MODE	AUTO
VOLTS/CM (CH 1 or CH 2)	5 V
SOURCE (A and B)	LINE
TIME/CM (A and B)	2 mSEC

(b) Connect the 10 : 1 probe between the INPUT (CH1 or CH2) and the line voltage.

CHECK - 1
The display must be triggered by the line voltage.

OPERATION - 2
Set the HORIZ DISPLAY switch to the DLY'D (B) position.

CHECK - 2
The display must be triggered by the line frequency. Remove the probe from the synchroscope, after the check is completed.

33. A Sweep Time Accuracy

REQUIREMENT
The A sweep time accuracy must be within ±3% of the TIME/CM switch indication.

OPERATION
(a) Change the SOURCE (A and B) switches to the INT position.
(b) Set the A TIME/CM VARIABLE control to the CALIB position.
(c) Prepare a time marker generator and a signal generator. Feed signals to the vertical input as given in Table 6-4 to check accuracy of A sweep time at each TIME/CM switch position.
(d) Align the starting pulse to the leftmost vertical scale.

CHECK
Position of displayed 11th pulse (or 21st pulse or end of 10th cycle, refer to Table 6-4) must not deviate from the rightmost vertical scale by more than 3 mm (3%).
In other words, when the A sweep time is correct in the 1 mSEC range, markers should appear at each vertical scale (1 cm interval) and the 11th pulse should coincide with the rightmost vertical scale.
Similarly, when the A sweep time is correct in the 2

mSEC range, marker pulses should appear at every 0.5 cm, and the 21st pulse should fall on the rightmost vertical scale.

Table 6–4 A and B sweep time accuracy

A, B TIME/CM	Signal source		Number of waveform in viewing area
	Signal generator	Time marker generator	
10 nSEC	100 MHz		1 cycle/cm
20 "	50 MHz		1 cycle/cm
50 "	20 MHz		1 cycle/cm
.1 μSEC		0.1 μSEC	1 maker/cm
.2 "		0.1 "	2/cm
.5 "		0.5 "	1/cm
1 "		1 "	1/cm
2 "		1 "	2/cm
5 "		5 "	1/cm
10 "		10 "	1/cm
20 "		10 "	2/cm
50 "		50 "	1/cm
.1 mSEC		100 "	1/cm
.2 "		100 "	2/cm
.5 "		500 "	1/cm
1 "		1 mSEC	1/cm
2 "		1 "	2/cm
5 "		5 "	1/cm
10 "		10 "	1/cm
20 "		10 "	2/cm
50 "		50 "	1/cm
.1 SEC		100 "	1/cm
.2 "		100 "	2/cm
.5 "		500 "	1/cm
For A sweep only			
1 SEC		1 SEC	1/cm
2 SEC		1 SEC	2/cm
5 SEC		5 SEC	1/cm

34. B Sweep Time Accuracy

REQUIREMENT

The B sweep time accuracy must be within ±3% of the TIME/CM switch indication.

OPERATION

(a) Change the HORIZ DISPLAY switch to the DLY'D (B) position.
(b) Set the VARIABLE control of B TIME/CM control to the CALIB position.
(c) Feed signals as described in Table 6-4 from the marker generator and signal generator.
(d) Align the starting pulse of display to the leftmost vertical scale.

CHECK

Position of the displayed 11th pulse (or 21st pulse or end of the 11th cycle) must not deviate from the rightmost vertical scale by more than 3 mm (3%).

35. A and B Sweep Linearity

REQUIREMENT

The linearity of A and B sweep must be within 3% in each TIME/CM switch range in the center eight divisions, i.e. between four division left and right of the center vertical scale.

OPERATION - 1

(a) Change the HORIZ DISPLAY switch to the A position.
(b) Connect the time marker generator to the vertical input and adjust signal frequency so that the pulses will be displayed at 1 cm interval. For TIME/CM switch ranges higher than 50 nSEC, use a standard signal generator instead of the time marker generator. (Sine waves will appear in this case.)

CHECK - 1

Measure the largest and the smallest pulse intervals in the eight divisions of horizontal scale. Calculate the sweep linearity by using the following formula.

$$\text{Linearity (\%)} = \frac{(\text{maximum pulse interval}) - (\text{minimum pulse interval}) \times 2}{(\text{maximum pulse interval}) + (\text{minimum pulse interval}) \times 100}$$

OPERATION - 2

(a) Change the HORIZ DISPLAY to the DLY'D (B) position.
(b) Repeat step (b) in Operation - 1.

CHECK - 2

Repeat the steps in Check - 1.

36. Accuracy and Linearity of X10 Magnification in A and B Sweep

REQUIREMENT

Accuracy and linearity of X10 magnification are shown in Table 6-5.

Table 6–5 Accuracy and linearity of X10 magnification in A and B sweep

A, B TIME/CM	Signal source		Number of waveform in cycles	Accuracy of magnified sweep	Linearity of magnified sweep
	Signal generator	Time marker generator			
10 nSEC	100 MHz		½ cycle/5 cm	approx. ±10 %	
20 "	"		1 cycle/5 cm	±10 % (Length of one cycle should be within 45 to 55 mm, except the first five cycles.)	
50 "	"		2.5 cycle/5 cm	± 7 % (Length of 2.5 cycles should be between 46.5 mm and 53.5 mm, except the first seven cycles.)	
.1 μSEC	"		1 cycle/cm	± 5 % (Length of 9 cycles should be between 85.5 and 94.5 mm, except the first 5 cycles.)	
.2 "		0.1 μSEC	2 marker/cm	± 5 % (Eighteen marker pulses should fall between 85.5 and 94.5 mm.)	
.5 "		0.5 "	1/cm	± 5 % (Nine marker pulses should fall between 85.5 to 94.5 mm.)	
1 "		1 "	1/cm		
2 "		1 "	2/cm		
5 "		5 "	1/cm		Formula for sweep linearity calculation. Linearity (%) = $\frac{2(\text{maximum value} - \text{minimum value})}{(\text{maximum value} + \text{minimum value})} \times 100$
10 "		10 "	1/cm		
20 "		10 "	2/cm		
50 "		50 "	1/cm		
.1 mSEC		100 "	1/cm		
.2 "		100 "	2/cm		
.5 "		500 "	1/cm	±5 % (When the marker interval is 1 marker/cm, nine marker pulses should fall between 85.5 mm and 94.5 mm. When the interval is 2 marker/cm, 18 marker pulses should be in the same distance.)	±5 % (When the marker interval is 1 marker/cm, measure the maximum and minimum distance between two markers (one marker interval). When the marker interval is 2 markers/cm, measure the maximum and minimum values of two marker intervals.
1 "		1 mSEC	1/cm		
2 "		1 "	2/cm		
5 "		5 "	1/cm		
10 "		10 "	1/cm		
20 "		10 "	2/cm		
50 "		50 "	1/cm		
.1 SEC		100 "	1/cm		
.2 "		100 "	2/cm		
.5 "		500 "	1/cm		
1 "		1 SEC	1/cm		
2 "		1 "	2/cm		
5 "		5 "	1/cm		

NOTE: Unless otherwise specified, the ratings apply to the entire sweep length.

OPERATION - 1
(a) Change the HORIZ DISPLAY to the A position.
(b) Change the MAG switch to the X10 position.
(c) Feed signal generator or time marker signal to the vertical input, as given in Table 6-5.

CHECK - 1
Proceed with instructions given in Table 6-5.

OPERATION - 2
Change the HORIZ DISPLAY to the DLY'D (B) position.

CHECK - 2
Repeat the steps in Check - 1.

37. Center Shift in MAG Operation

REQUIREMENT
When the sweep is magnified by X10, the center of the display must not shift horizontally more than 5 mm.

OPERATION
(a) Change the HORIZ DISPLAY switch to the A position.
(b) Set the A TIME/CM switch to the 1 mSEC position.
(c) Return the MAG switch to the X1 position.
(d) Adjust the horizontal POSITION to start the sweep from the center vertical scale.
(e) Change the MAG switch to X10.

CHECK
The starting point of the sweep must not shift horizontally, when the MAG switch is changed from X1 to X10 positions, more than 5 mm.

38. DELAY TIME MULTI Dial

REQUIREMENT
Deviation of the DELAY TIME MULTI dial scale from vertical graduation on the viewing area must be smaller than 10 divisions (1/10 of one turn of the dial) in the dial range between 1.00 and 9.00.

OPERATION
(a) Remove measuring instruments, if any, from inputs of the synchroscope.
(b) Change control settings as shown below.

HORIZ DISPLAY	A INTEN BY B
A TIME/CM	1 mSEC
B TIME/CM	0.1 mSEC
MAG	X1
A SWEEP MODE	AUTO
DLY'D (B)	AUTO

(c) Trigger the sweep and align the starting point of the sweep free run to the leftmost vertical scale.
(d) Turn the DELAY TIME MULTI dial to set the starting point of the intensified part on the display to the second vertical graduation (1 cm from the leftmost end). Change the starting point of the intensified part to the third vertical graduation, repeat the shift until the intensified part starts from the 10th vertical graduation (1 cm from the rightmost end of the graticule).

CHECK
Read the dial indication every time the starting point of the intensified part is set to a vertical graduation. The dial indication must be within 10 divisions of the digit scale (1.00 to 9.00).

39. Delay Time Range

REQUIREMENT
The delay time must cover the range from 1 μSEC to 50 SEC.

OPERATION
(a) Set the A TIME/CM VARIABLE control to the CAL position.
(b) Set the starting of sweep to the leftmost vertical scale, and trigger the sweep.

CHECK
The starting point of the intensified part of the display must move from the second vertical graticule (1 cm from the leftmost end) to the 11th vertical graticule (the rightmost end) when the DELAY TIME MULTI dial is rotated through its full range. Repeat this test for each combination of A and B TIME/CM switch position given in Table 6-6.

Table 6–6 Delay time operating range

A TIME/CM	B TIME/CM
1 μSEC	.1 μSEC
2 "	.2 "
5 "	.5 "
10 "	1 "
20 "	2 "
50 "	5 "
.1 mSEC	10 "
.2 "	20 "
.5 "	50 "
1 "	.1 mSEC
2 "	.2 "
5 "	.5 "
10 "	1 "
20 "	2 "
50 "	5 "
.1 SEC	10 "
.2 "	20 "
.5 "	50 "
1 "	.1 SEC
2 "	.2 "
5 "	.5 "

40. Jitter in Delayed Sweep

REQUIREMENT
The jitter in delayed sweep must be within 1/20,000 of A sweep length.

OPERATION
(a) Change the control settings as shown below

A TIME/CM	1 mSEC
B TIME/CM	0.5 μSEC
A SLOPE	+
DELAY TIME MULTI	9.00

(b) Connect the CAL OUT to the CH1 INPUT, set the display amplitude to 20 mm or more, and trigger the sweep adequately by using the LEVEL (A) control.
(c) Change the HORIZ DISPLAY switch to the DLY'D (B) position, and turn the DELAY TIME MULTI dial gradually around the 9.00 point to move the leading edge of the delayed square wave to the center of the viewing area.

CHECK
The jitter in the display must be less than 9 mm in width, excluding slow drift.

ADDITIONAL OPERATION
Remove the test signal connection.

41. External Input Sensitivity in TRIG OR HORIZ INPUT

REQUIREMENT
The external horizontal input sensitivity in the EXT mode must be 100 mV/cm (±20%), and 1 V/cm (±25%) in the EXT ÷ 10 mode.

OPERATION - 1
(a) Change the control settings as shown below.

HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	EXT
COUPLING (B)	DC

(b) Connect a sine wave generator to the TRIG OR HORIZ INPUT, set the signal frequency to 1 kHz and signal level to 200 mV p-p.

CHECK - 1
Horizontal amplitude of the display must be between 16 and 24 mm.

OPERATION - 2
(a) Change the SOURCE (B) switch to the EXT ÷ 10 position.
(b) Change the sine wave generator output to 2 V p-p.

CHECK - 2
The horizontal amplitude of display must be between 15 and 25 mm.

42. TRIG OR HORIZ INPUT Bandwidth

REQUIREMENT
The bandwidth of the external horizontal amplifier must be within -3 dB at 1 MHz.

OPERATION
(a) Change the SOURCE (B) switch to the EXT position.
(b) Terminate the signal generator output with a 50-ohm termination, and connect the output to the TRIG OR HORIZIINPUT. Set the generator frequency to 50 kHz.
(c) Adjust the generator output to set the horizontal amplitude of display to 40 mm. Do not change the output level in the following step.
(d) Change the generator frequency to 1 MHz.

CHECK
The horizontal amplitude of display at 1 MHz must be larger than 28 mm.

ADDITIONAL OPERATION
Disconnect the test connection.

43. External Input Sensitivity in CH2 INPUT

REQUIREMENT
The external horizontal input sensitivity of the CH2 INPUT must be 5 mV/cm ± 5%.

OPERATION
(a) Change the control setting as shown below.

HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
TRIGGER	CH 1
MODE	CH 1
VOLTS/CM (CH 2)	5 mV

(b) Connect a sine wave generator to the CH2 INPUT, and set the signal output to 20 mV p-p at 1 kHz.

CHECK
The horizontal amplitude of the display must be between 38 and 42 mm

44. CH2 INPUT Bandwidth in External Horizontal Input

REQUIREMENT
The frequency characteristics of CH2 INPUT must be within -3 dB at 1 MHz.

OPERATION
(a) Connect a standard signal generator to the CH2 INPUT set the generator frequency to 50 kHz.
(b) Adjust the generator output to set the horizontal amplitude of display to 40 mm. Keep the same generator output level against change in frequency.
(c) Change the frequency to 1 MHz.

CHECK
The horizontal amplitude of display must be at least 28 mm at 1 MHz.

45. X - Y Phase Difference

REQUIREMENT
The phase difference between the X and Y axis must be within ±3° at 100 kHz.

OPERATION
(a) Change the VOLTS/CM (CH1 and CH2) switches to the 5 mV position.
(b) Connect the signal generator output to the CH1 and CH2 inputs.
(c) Set the signal generator frequency to 100 kHz, and adjust the signal output to set the vertical and horizontal display amplitudes respectively to 40 mm.
(d) Position the display at the center of viewing area.

CHECK
Distance between cross-points of the display at the vertical center line of the graticule must be small than 2 mm (equivalent to a phase difference of 3° or less). Refer to Figure 6-6.

ADDITIONAL OPERATION
Disconnect the test connections.

46. TRACE FINDER Operation (Horizontal Direction)

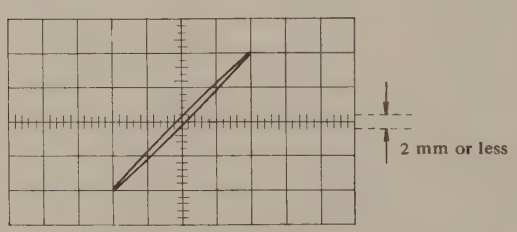
REQUIREMENT
When the TRACE FINDER button is depressed, traces must remain in the viewing area through full rotation of the horizontal POSITION control.
(a) Change the HORIZ DISPLAY switch to the A position, and position the starting point of sweep to the leftmost vertical scale.
(b) Depressing the TRACE FINDER button, turn the horizontal POSITION control through its full rotation range.

CHECK
The trace should remain in the viewing area against through rotation of the POSITION control.

47. CALIBRATOR Repetition Frequency

REQUIREMENT
The repetition frequency of the CALIBRATOR must be 1 kHz ±1%.

Figure 6–6 X–Y Phase Difference



OPERATION
(a) Change the MODE switch to the CH1 position.
(b) Change the A SWEEP MODE switch to the AUTO position.
(c) Set the A and B TIME/CM switches to the .5 mSEC position. (d)
(d) Set the time marker generator frequency to 1 mSEC, connect marker output to the CH1 INPUT, and adjust the A TIME/CM VARIABLE control so the marker pulses will be displayed at 1 cm intervals.
(e) Align the first marker pulse to the leftmost vertical scale.
(f) Disconnect the marker generator from the input and connect the CAL OUT terminal to the CH1 INPUT.

CHECK
The 10th cycle of calibrator signal must end within ±1 mm (±1%) of the rightmost vertical scale.

48. CALIBRATOR Duty Cycle

REQUIREMENT
The duty cycle of the CALIBRATOR output signal must be better than 49 : 51.

OPERATION
Set the A and B TIME/CM switches to the 50 μSEC position, and adjust the A VARIABLE control so that one cycle of the CALIBRATOR square wave will be displayed in exactly 100 mm.

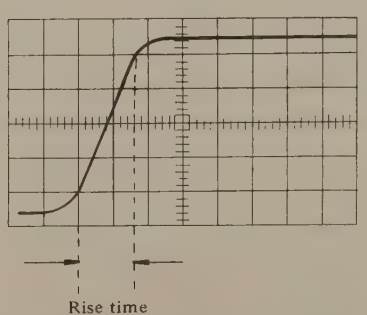
CHECK
One half cycle of the CALIBRATOR square wave must end within 1 mm of the vertical center line.

49. CALIBRATOR Rise Time

REQUIREMENT
The CALIBRATOR square wave output must rise within 0.1 μSEC.

OPERATION
(a) Change the VOLTS/CM switch (CH1) to the 1 position.

Figure 6–7 Rise time of CALIBRATOR output signal



(b) Set the CALIBRATOR VOLTS switch to the .5 position.
(c) Change the A and B TIME/CM switches to the 20 nSEC., and set the A VARIABLE control to the CALIB position.
(d) Change the SLOPE (A) switch to the + position.
(e) Adjust the LEVEL (A) control to ease observation of the leading edge of the waveform.
(f) Adjust the POSITION (CH1) control to align the center of the display (50 mm in amplitude) with the central vertical scale. (Refer to Figure 6-7).

CHECK

Horizontal distance between 10% and 90% points on the leading edge of the waveform must be within 50 mm (0.1 uSEC).

ADDITIONAL OPERATION

Disconnect the test connection.

50. CALIBRATOR Voltage Accuracy

REQUIREMENT

The accuracy of CALIBRATOR output voltage must be within 2% of the switch indication, 5 mV to 10 V.

OPERATION

(a) Change the control setting as shown below.

VOLTS/CM (CH 1)	5 mV
CALIBRATOR VOLTS	5 mV
A and B TIME/CM switches	10 mSEC

(b) Connect a sine wave generator to the CH1 INPUT. Set the signal frequency to 1 kHz and the signal level to 5 mV p-p.
(c) Disconnect the sine wave generator from the CH1 INPUT, and connect the CAL OUT to the input through a coaxial cable.

CHECK

The vertical amplitudes of the signal generator output and the CAL OUT output must coincide within ±2%.

CAUTION: Repeat the same check for all CAL OUT voltage ranges, 10 mV to 10 V. For these voltage ranges, increase the display amplitude to 2 cm or more. It eases precise checking.

ADDITIONAL OPERATION

Disconnect the test connection.

51. A GATE and B GATE Outputs

REQUIREMENT

The A and B gate output voltages must be a square wave having an amplitude of 6 V ± 10%.

OPERATION

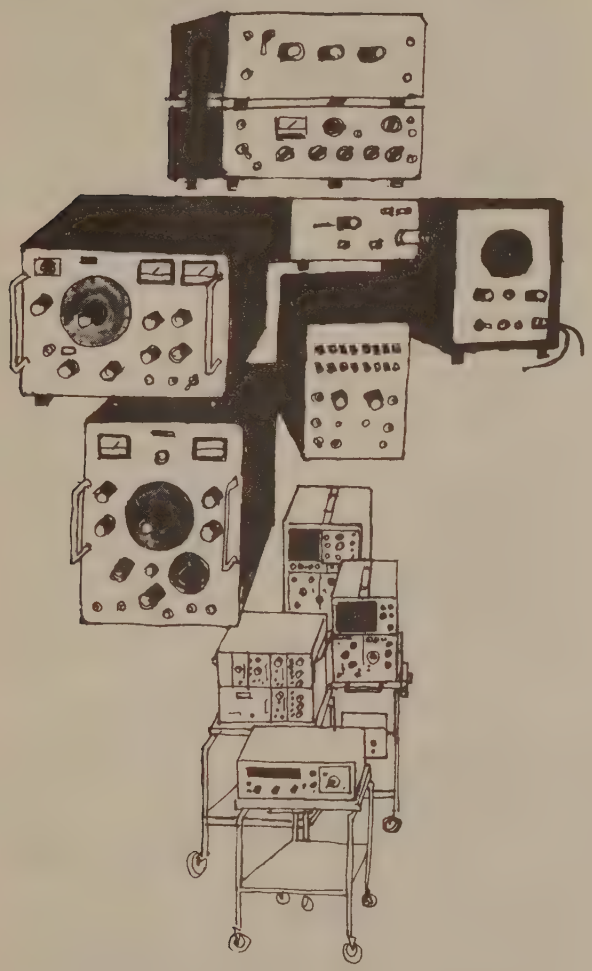
(a) Change the HORIZ DISPLAY switch to the A INTEN BY B position.
(b) Change the A and B TIME/CM switches to the 1 mSEC position.
(c) Set the DELAY TIME MULTI dial to 1.00.
(d) Prepare a test synchroscope and observe outputs of A GATE and B GATE (located on the right side panel).

CHECK

The gate output voltages must be a square wave 6 V ± 10% in amplitude.

notes

CHAPTER 7 CALIBRATION



Like any other precision test instruments, calibration of the synchroscope is required after a certain period of use. The type of calibration required, whether overall or partial, depends on conditions of the synchroscope at such time. Procedures for calibration are described in Chapter 6, and careful reference to the chapter should be made when calibrating.

Recalibration is usually required after maintenance of the synchroscope. Such requirement, however, depends on the nature of the maintenance performed.

When calibration or adjustment of a partial stage or section of the instrument is performed, caution should be observed, since such a partial stage or section is electronically interconnected with other stages or sections of the instrument. For example, the regulated DC supply section is directly related with performance of the entire stages or sections, and CRT high voltage is also directly related with horizontal and vertical deflection sensitivity.

Highly accurate test instruments and qualified skill are required for the following calibration procedures. Factory calibration is recommended, when reliable test instruments are not available. In such cases, contact IWATSU's service engineer or our nearest representative.

Instruments Required for Calibration 7– 2
Precautions and Preliminary Setting for Calibration. 7– 3
1. Low Voltage Power Supply (DC Voltage).... 7– 3
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▷ Instruments Required for Calibration

Various types of test instruments are required for calibration of the synchroscope SS-212. Specifications of such instruments required and some precautions to be taken are described in this section.

(1) BNC type connectors are used in synchroscope SS-212. If the output connector of test instrument is not the BNC type, an adaptor for the BNC connector will be required for connection of the test cable.

(2) Characteristics and accuracy of test instrument should be equivalent to or better than those described herein. The instrument must be properly calibrated.

(3) When using signal generators, be sure to terminate the generator output with a proper termination.

(4) Ordinarily, sine wave signal generators, are calibrated for effective value (rms value). Note that voltages in SS-212 indicate the peak-to-peak value. The effective value of a sine wave signal is represented by the peak-to-peak value as shown below.

$$\text{Voltage (rms)} = \frac{\text{Voltage (p-p)}}{2\sqrt{2}}$$

1. Variable Auto-Transformer

Power capacity (or rating)	200 VA
Variable voltage range	90 volts to 126 volts for 100 V AC line 180 volts to 253 volts for 200 V AC line

AC voltmeter to check output voltage must be provided.

2. DC Voltmeter [1]

Accuracy	0.5%
Sensitivity	1 kilohms/volt or more
Measurable voltage range	15 V to 150 V

3. DC Voltmeter [2]

Accuracy	2%
Sensitivity	20 kilohms/volt or more
Measurable voltage range	0 V to 1000 V, 2500 V

4. DC Voltmeter [3]

Accuracy	2% without probe 10% with 100: 1 probe
Sensitivity	10 Megohms/volt without probe 1000 Megohms/volt with 100 : 1 probe
Measurable voltage range	0 to 1000 V without probe

5. Synchroscope Oscilloscope

Vertical deflection sensitivity	5 mV/cm or more
Frequency bandwidth	DC to 50 MHz

6. Capacitance Meter

Measurable capacitance range	0 to 100 pF

7. Since Wave Generator

Frequency	10 Hz to 50 kHz
Output level	1 mV to 7.75 V (rms)
Output level accuracy	2% (must be calibrated better than 0.5% at 1 kHz).

NOTE: For more accurate measurement, a resistor attenuator with maximum attenuation 10 dB (0.1 dB step) must be used.

8. A sine wave signal generator known as the standard signal generator (SSG).

For proper operation check of SS-212, oscillating frequency of the signal generator must be extended from 50 kHz to 200 MHz or higher. Ordinarily, two generators will have to be used to cover the frequency range continuously. Normally, the lower range generator covers 50 kHz to 50 MHz, and the higher range generator covers 10 MHz to 480 MHz.

Frequency range
1. 50 kHz to 50 MHz
2. 10 MHz to 200 MHz

Output level	1 mV to 1 V rms
Output level accuracy	±1 dB

9. Time Marker Generator

Marker output	0.1 μSEC to 5 SEC
Accuracy	0.1%

10. Square Wave Generator (I)

Rise time	0.1 μSEC or less
Output voltage	5 mV to 50 V
Repetition frequency	1 kHz
Waveform	must have low distortion

11. Square Wave Generator (II)

Rise time	20 nSEC or less
Output voltage	0 to 1 V
Repetition frequency	60 Hz, 1 kHz, 15 kHz, 100 kHz, 250 kHz 1 MHz
Waveform	must have low distortion

12. Square Wave Generator (III)

Rise time	500 pSEC or less
Output voltage	0 to 1 V
Repetition frequency	50 Hz or more
Waveform	must have low distortion

13. Square Wave Generator (IV)

Rise time	3 nSEC or less
Output voltage	0 to 1 V
Repetition frequency	400 kHz to 1 MHz
Waveform	must have low distortion

14. Auxiliary Parts

(a) Coaxial cable — 50 ohms

(b) 50-ohm termination (2 required)
Used to terminate output of square wave or standard signal generator. For example, IWATSU BB50M1 (BNC) or equivalent.

(c) BNC T-type connector

(d) Signal divider
A coaxial connector to branch high frequency signal. A certain signal loss is inherent in this connector. IWATSU B-50D3 (BNC) or its equivalent should be used.

(e) Coaxial attenuator
An attenuator to reduce output voltage of square wave generator. When the generator is provided with a calibrated output attenuator, the coaxial attenuator may not be required. IWATSU AA series attenuator or its equivalent should be used.

(f) Plug-in unit extension connector
Two types of plug-in unit extension connector, for vertical plug-in and for horizontal plug-in unit, are available. These plug-in unit extension connector are for electrically connecting SS-212 basic unit and plug-in unit when adjusting the plug-in unit off the SS-212 basic unit. The plug-in unit extension connector provides a female connector one end and male connector the other end. The plug-in unit extension connector is available from IWATSU.

▷ Precautions and Preliminary Setting for Calibration

Prior to calibration

(1) Remove top, bottom and side covers.
(2) Connect the variable Auto-Transformer to power line prior to connecting the synchroscope SS-212 to output of the Auto-Transformer.
(3) Check that the LINE VOLTAGE RANGE switch on the rear panel of the SS-212 is moved to the correct position for the line voltage available. Set output voltage of the Auto-Transformer to center value of the switch setting. Connect the synchroscope SS-212 to output of the Auto-Transformer.
(4) Set INTENSITY control maximum counterclockwise and turn POWER switch on.
(5) For higher accuracy calibration, keep ambient temperature +25°C to +5°C and allow at least one hour for warm up time.

Caution on use of the plug-in unit extension connector

Calibration of the plug-in unit without removing it from the basic rack unit is rather limited, and usually removal from the basic rack unit is required. The plug-in unit extension connector (two types, for vertical plug-in unit and for horizontal plug-in unit, are available) are used for electrical connection of SS-212 basic rack unit and off-set plug-in unit for calibration. Power should be turned off when the plug-in unit is removed the basic rack unit, and when the plug-in unit extension connector are connected or disconnected.

1. Low Voltage Power Supply (DC Voltage)

It is recommended that the low voltage power supply be checked prior to calibrating any other area of the instrument as it may affect performance of the entire circuit, if it is functioning improperly.

(a) Test equipment required
DC voltmeter [1]
Synchroscope oscilloscope
(b) Check voltage and ripple contents across the test points shown in Figure 7-1 and the ground point for correct voltages given in Table 7-1.
(c) Accuracy of the DC voltmeter used for this test should be 0.5% or better.
(d) An synchroscope may be used for measurement of ripple contents.
(e) Specifications for calibration of the DC power supply is given in Table 7-1 and the variable resistors for use for the calibration are shown in Figure 7-1.

2. High Voltage Power Supply

Variation of voltage of high voltage supply affects deflection sensitivity of vertical and horizontal axes of the CRT, and large variation will affect Intensity and Focus. Two major checkpoints on the high voltage supply are shown in Table 7-2.

(a) Test equipment required
DC voltmeter [2]
DC voltmeter [3]
(b) First check voltage on CRT Cathode. Set voltage range of the DC voltmeter [2] to measure 1,450 volts or higher and connect the voltmeter across the test point shown in Figure 7-1 and ground terminal.
(c) Adjust H. V. ADJ R900 (see Figure 7-2) for voltage reading of -1,450 V.
(d) Disconnect the voltmeter [2] and check voltage on the CRT anode by use of the voltmeter [3].

CAUTION: The anode electrode of the CRT is located toward left hand side of the CRT when faced from the front. Very high voltage is present on the anode (+13 kV to +14 kV) and such high voltage remains charged in a static charge form even after power switch of the instrument is turned off. Direct touch of the anode with hands should absolutely be avoided as it may cause a dangerous shock hazard.

(e) Turn the power switch off and allow about 10 minutes or more with power turned off. Remove the anode cap without removing insulated cap cover. Keep your hands or body away from the exposed anode cap and anode electrode.
(f) Discharge high voltage charged on the anode and the anode cap by grounding them to the instrument ground terminal or grounded chassis. Caution should be taken for the operation as it is hazardous.
(g) Connect the probe to the DC voltmeter [3]. Connect the terminal lead of the voltmeter to the ground terminal of the instrument and the probe to the anode cap. A reliable insulation between the anode

Table 7–1

Power supply	Type	Color code of wiring	Tolerance	Ripple (peak to peak)	Sequence	Variable resistor for adjustment
−15 V	Regulated	White/black	0 %	250 μV or less	1	R1062
+15 V	"	White/red	0 %	250 μV or less	2	R1044
+75 V	"	Red (white)/blue	0 %	3 mV or less	3	R1025
+150 V	"	Red (white)/yellow	0 %	2 mV or less	4	R1009

cap and the probe, and other circuit of the instrument should be maintained during the voltage check, as improper insulation may cause high voltage arcing when power is on.

(h) Turn the power switch on, and leave the instrument for several minutes.

Check the anode voltage, The voltage should read between +13 kV and +14 kV. Measurable voltage range of the probe and the voltmeter setting should be 15 kV or higher.

(i) Turn the power switch off, and discharge high voltage charged in the high voltage supply circuit.

(j) Reinstall the anode cap to the anode electrode of the CRT and be sure that the cap is secured in position.

(k) Remove the voltmeter connections.

(l) Turn the power switch on.

Table 7–2

High Voltage power supply	Color code of wiring	Normal value
CRT cathode voltage	White/green	−1,450 V ±1 %
CRT anode voltage	Red	+13 kV – +14 kV

3. Intensity

Poor intensity will hamper observation of display of the characteristics pattern on the CRT screen, while excessive intensity may burn out phosphor coating of the CRT screen.

(a) Set the related controls as follow:

BAND WIDTH	50 MHz
HORIZ DISPLAY	A
A SWEEP MODE	SINGLE
A TIME/CM	1 mSEC
MAG	X1

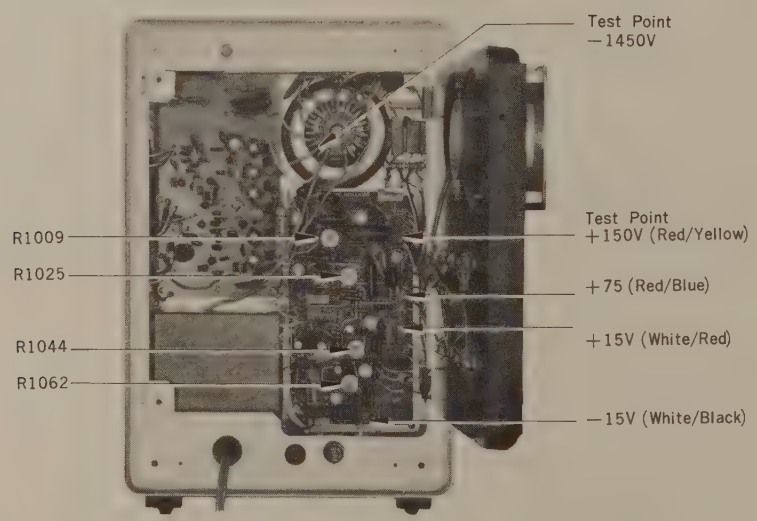
(b) With INTENSITY control setting at maximum clockwise, adjust the INTEN ADJ R911 (Fig. 7-5) until clear visible spot is obtained.

(c) Set the A SWEEP MODE switch to the AUTO position and the INTENSITY control to maximum clockwise, the spot should disappear.

4. Uniformity of Intensity of the Swept Traces

Intensity of the swept traces should be so adjusted that uniformity of intensity over the entire sweep speed be obtained.

Figure 7–1 Rear View



(a) Test equipment required

DC voltmeter [2]	Internal resistance of 20 K Ohm per volt

(b) Set controls as shown below

HORIZONTAL DISPLAY	A
A SWEEP MODE	SINGLE
VARIABLE (A TIME/CM)	CALIB
MAG	X1

(c) Turn the power switch off. Set the voltmeter to approximately 30 volt range, and connect the positive terminal lead of the voltmeter to the test point on the collector of TR809 (see Figure 7-1), the negative terminal lead to the ground terminal of the instrument. Turn the power switch on.

CAUTION: Caution should be taken that the instrument power should be always turned off when the DC voltmeter connection to TR809 is made, otherwise transistor damage may result.

(d) Adjust the horizontal POSITION control to position the spot to the center of the CRT screen. Adjust R855 for the voltmeter reading of +10 V (see Figure 7-2).

(e) Turn the power switch off, and disconnect the voltmeter. Turn the power switch on.

(f) Set the A SWEEP MODE to AUTO for free running of the swept traces.

Changing the A TIME/CM switch positions sequentially from 10 nSEC to 50 nSEC, adjust R818, C803 and R843 (see Figure 7-1) until uniform intensity of the swept trace over the entire trace length is obtained.

5. Low Voltage Power Supply (DC Voltage) Regulation

Improper regulation of the regulated low voltage power supply may cause operating performance of the instrument to fall outside rated specifications.

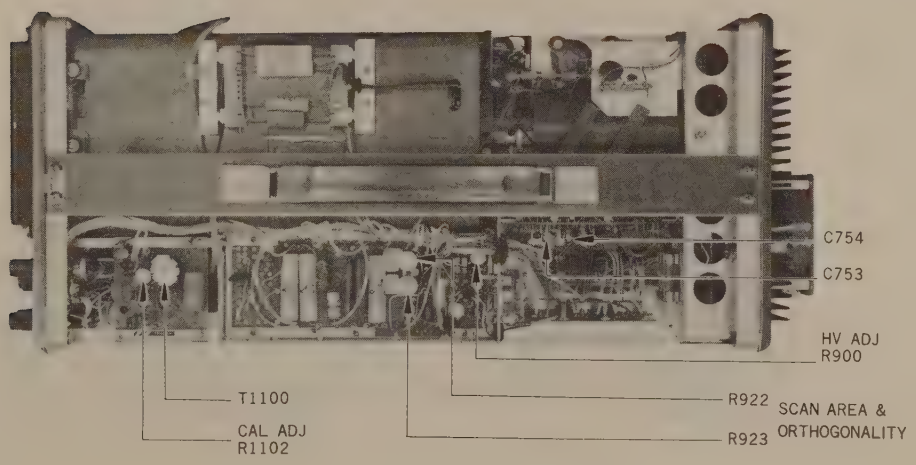
(a) Set the HORIZ DISPLAY switch to A and the TIME/CM switch to 10 mSEC connect the CAL OUT to the CH1 INPUT, set the display amplitude to 20 mm on the screen, and trigger the sweep.

(b) Vary AC line voltage supplied to the instrument through the Auto-Transformer plus 10% and minus 10% of the center value of the voltage setting with LINE VOLTAGE RANGE switch.

(c) Signs of intensity modulation on the trace and increase in ripple contents should not appear on the CRT screen with plus and minus 10% AC line voltage variations.

(d) Return voltage of the Auto-Transformer output to the center value.

Figure 7–2 Top View



6. Screen X-Y Scale Calibration

Correctly aligned X-Y scale may sometimes be influenced by outside magnetic fields.

(a) Test equipment required
Sine wave generator

(b) Disconnect the CAL OUT from CH1 INPUT.

(c) Sweep the display, and adjust the TRACE ROTATION control, located at the right hand side of the instrument front panel, until the swept horizontal line trace coincides with the horizontal center line of the scale on the CRT screen.

(d) Short circuit the vertical amplifier output, the swept horizontal line trace may be displaced from the horizontal scale center line. Adjust R922 and R923 (see Figure 7-2) until the swept horizontal line trace can be placed right on the horizontal scale center line. Setting of R922 close to mechanical center of the entire range of rotation is recommended in this adjustment.

(e) Remove the short circuit in the outputs of the vertical amplifier. Feed a signal to the INPUT connector, place the sweep mode in the AUTO position (free running) to display a raster, and overdrive the vertical amplifier. Confirm that the height of the raster exceeds the viewing area.

(f) Reduce the vertical amplitude of the raster by 6 cm, and adjust the top and the bottom edges of the raster to coincide with the graticule scale. Adjust the horizontal position of the display so that the raster starts from the center of the graticule as shown in Fig. 7-3. Adjust R922 and R923 so that the starting line of the raster coincides with the center vertical line of the graticule. These adjustments interact, therefore should be repeated until both are correct.

(g) If the alignment of the horizontal trace in item (c) deviates from the horizontal center line of the scale after the vertical alignment, adjust the TRACE ROTATION adjustment so that the horizontal trace coincides with the scale, and repeat items (c) to (f).

7. Adjustment of ASTIGMATISM

(a) Test equipment required
Sine wave generator

(b) Set the sine wave generator frequency to 1 kHz and feed the signal into the CH1 INPUT of the instrument. Adjust output level of sine wave generator until the amplitude of the sine wave on the CRT screen reaches 6 cm

(c) Set the A TIME/CM switch to the 1 mSEC position and trigger the sweep. Adjust the LEVEL (A) control, if display pattern will not hold still.

(d) Adjust the FOCUS and ASTIG controls (located on the front panel of the instrument) until a sharply focused display can be obtained throughout the entire viewing area.

8. Pattern Distortion

(a) Set the sine wave generator frequency to 20 kHz, and adjust output level until the display amplitude reaches to 6 cm on the screen.

(b) Leave the A TIME/CM switch to the 1 mSEC position to produce a raster display. Adjust the horizontal POSITION control to set the starting line of the display to the leftmost vertical scale.

(c) Adjust the INT SHIELD R925 and GEOMETRY R924 alternately (see Figure 7-5) to minimize deviation of raster from vertical and horizontal sides of graticule, as shown in Figure 7-4.

9. STEP ATTEN BAL (CH1, CH2)

Incorrect adjustment of the STEP ATTEN BAL control may cause shift in vertical position between the VOLTS/CM switch settings of 5 mV and 10 mV.

Figure 7–3 Raster

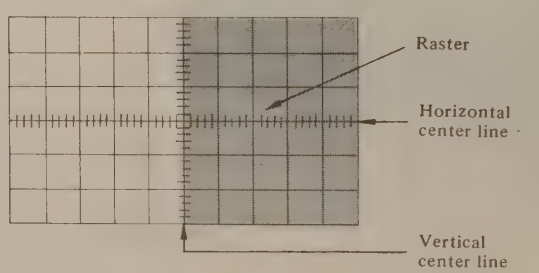
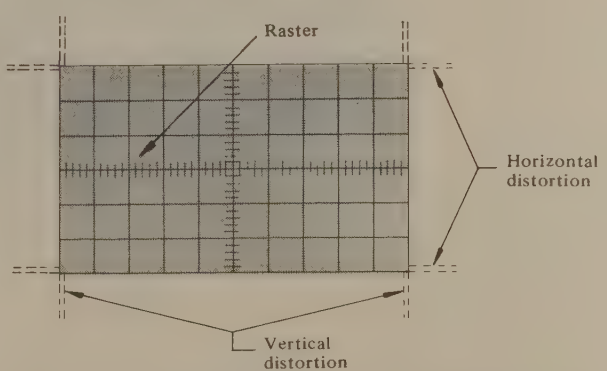


Figure 7–4 Pattern Distortion



(a) Set the AC-GND-DC switch to the GND position.
(b) Adjust to display the swept trace on the CRT screen.
(c) Set the VOLTS/CM switch alternately to 5 mV to 10 mV position, and adjust the STEP ATTEN BAL control (located on the front panel) so that the trace position is the same at either settings of 5 mV and 10 mV of the VOLTS/CM switch. Repeat the same adjustment for CH2.

10. Variable Bal. (CH1, CH2)

The VARIABLE BAL balances the amplifier so that no vertical shift of the trace occurs when the VOLTS/CM VARIABLE control is turned.
(a) Adjust the sweep circuit to display a trace.
(b) Adjust the VARIABLE BAL R38A/B (refer to Figure 7-6) until the trace position is held stable against variation of the VARIABLE control setting.

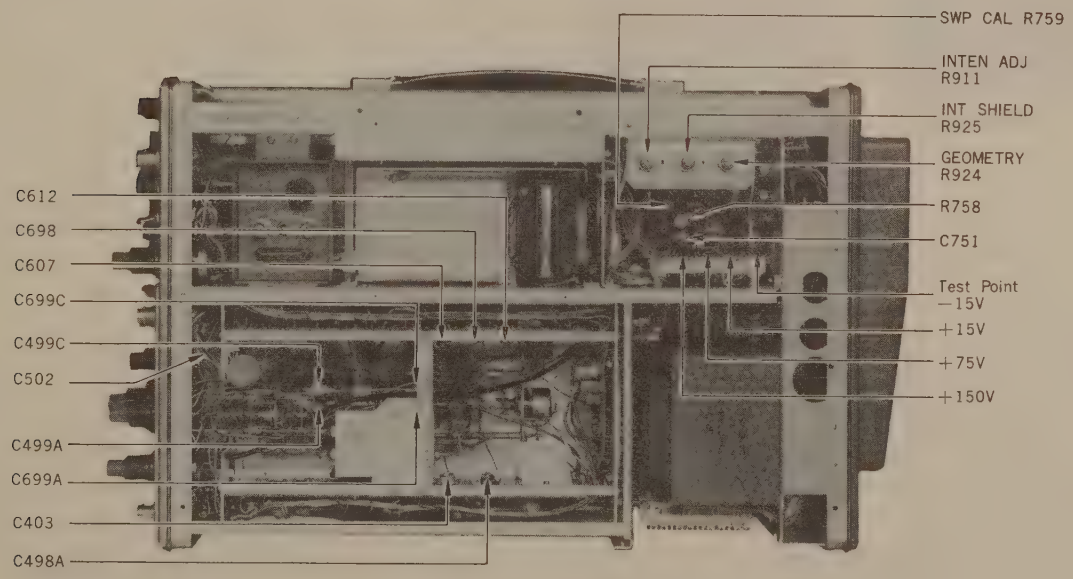
11. Diode Level (CH1, CH2)

(a) Test equipment required
Sine wave generator
(b) Set the generator frequency to 1 kHz and feed the signal to the CH1 INPUT.
(c) Turn the DIODE LEVEL R57A/B (refer to Figure 7-6) maximum counterclockwise. Adjust display amplitude to 2 cm on the CRT scale.
(d) Turn the DIODE LEVEL R57A/B clockwise gradually. The vertical amplitude of display should be increased with rotation of the control, till it reaches to a saturating point. This saturating point is the DIODE LEVEL point. Repeat the same adjustment for CH2.

12. Position Centering (CH1, CH2)

With correct adjustment of the POSITION CENTER R119A/B, with vertical position control setting at midrange, the trace will be positioned to the center of the CRT screen viewing area.
(a) Set the vertical POSITION control to the midrange.
(b) Adjust the POSITION CENTER R119A/B (refer to Figure 7-6) to position the trace to the center of the CRT screen graticule.

Figure 7–5 Right Side View



13. Vertical Deflection Sensitivity (CH1, CH2)

(a) Test equipment required

Sine wave generator (the generator should be calibrated that the accuracy of the output level is maintained at or less than 0.5% at 1 kHz).

(b) Turn the CH1 (CH2) VOLTS/CM VARIABLE to CALIB position and set the CH1 (CH2) AC-GND-DC to DC.

(c) Connect the signal generator output to the CH2 INPUT, feed in 1 kHz signal with amplitude of exactly 40 mV p-p, and set the MODE switch to CH2 position and the CH2 VOLTS/CM at the 10 mV position.

(d) Adjust the GAIN ADJ R226 (refer to Figure 7-6) to set the vertical amplitude of display correctly to 40 mm at the center area of CRT screen graticule.

(e) Set the MODE switch to CH1 position and the CH1 VOLTS/CM to 10 mV.

Apply the signal generator output to the CH1 INPUT and feed 1 kHz signal with amplitude of exactly 40 mV p-p.

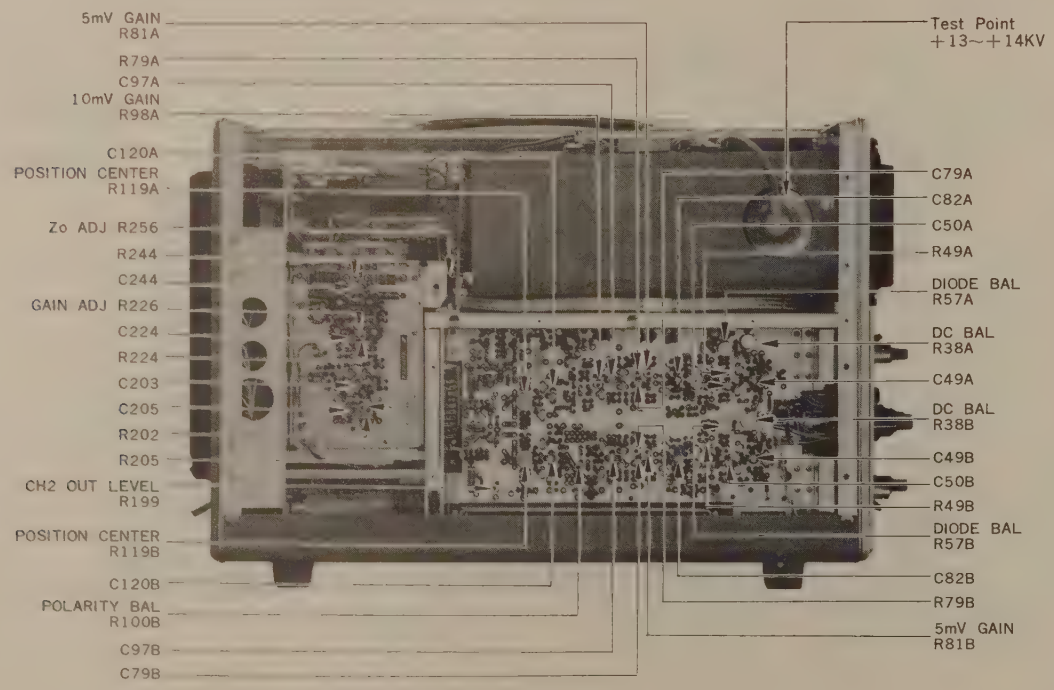
(f) Adjust the GAIN ADJ R98A (refer to Figure 7-6) to set the vertical amplitude of display correctly to 4 cm at the center area of CRT screen graticule.

(g) Set the CH1 VOLTS/CM to the 5 mV position, feed in signal with amplitude of 20 mV p-p. Adjust the 5

Table 7–3 Vertical deflection sensitivity

VOLTS/CM	Generator output level (at 1 kHz)	Vertical amplitude (cm)	Max. error at ±3 % level
5 mV	20 mVp-p	4	NOTE: ±0.2 mm at ±0.5 % these ranges only
10 mV	40 mVp-p	4	
20 mV	0.1 Vp-p	5	±1.5 mm
50 mV	0.2 Vp-p	4	±1.2 mm
.1 V	0.5 Vp-p	5	±1.5 mm
.2 V	1 Vp-p	5	±1.5 mm
.5 V	2 Vp-p	4	±1.2 mm
1 V	5 Vp-p	5	±1.5 mm
2 V	10 Vp-p	5	±1.5 mm
5 V	20 Vp-p	4	±1.2 mm

Figure 7–6 Left Side View



mV GAIN R81A (refer to Figure 7-6) to set the display amplitude correctly to 4 cm

(h) Set the MODE switch to CH2 and CH2 VOLTS/CM switch to the 5 mV position. Feed the 20 mV p-p signal to the CH2 INPUT. Adjust the 5 mV GAIN R81B (refer to Figure 7-6) to obtain correct display amplitude of 4 cm.

(i) With calibration of deflection sensitivity at 10 mV range, deflection sensitivity at the ranges above 20 mV should remain within ±3% of the range set value. Check deflection sensitivity in these ranges in accordance with Table 7-3.

14. Input Capacitance and Attenuator Compensation (CH1, CH2)

If the phase characteristics of the attenuator VOLTS/CM switch are not equal in each range, frequency response will deteriorate and distortion will occur in the displayed waveform.

The phase calibration trimmers can be adjusted from the front of the instrument as shown in Figure 7-7. The index plate of the front panel must be removed prior to phase calibration. Simply turn the screws counterclockwise to remove this plate without removing the knobs. (To install it align the tabs of the index plate with the corresponding front-panel holes.)

Table 7–4

VOLTS/CM Range	Calibrating Trimmer	
	Part A	Part B
5 mV		
10 mV		
20 mV	C11A/B	C1A/B
50 mV	C12A/B	C2A/B
.1 V	C13A/B	C3A/B
.2 V	C14A/B	C4A/B
.5 V	C15A/B	C5A/B
1 V	C16A/B	C6A/B
2 V	C17A/B	C7A/B
5 V	C18A/B	C8A/B

Figure 7–7

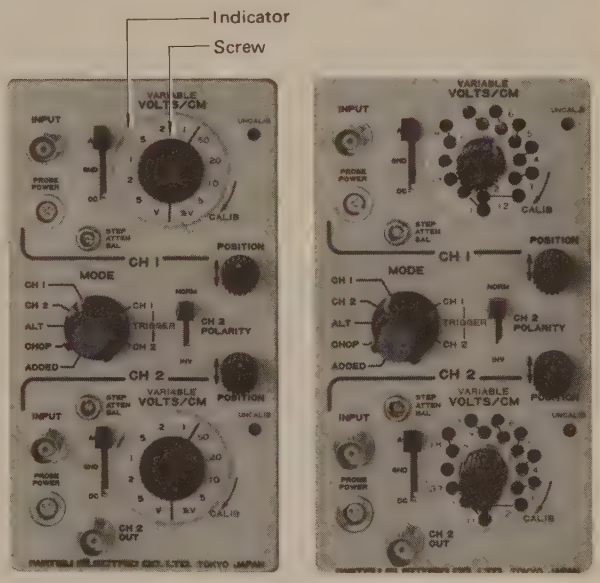
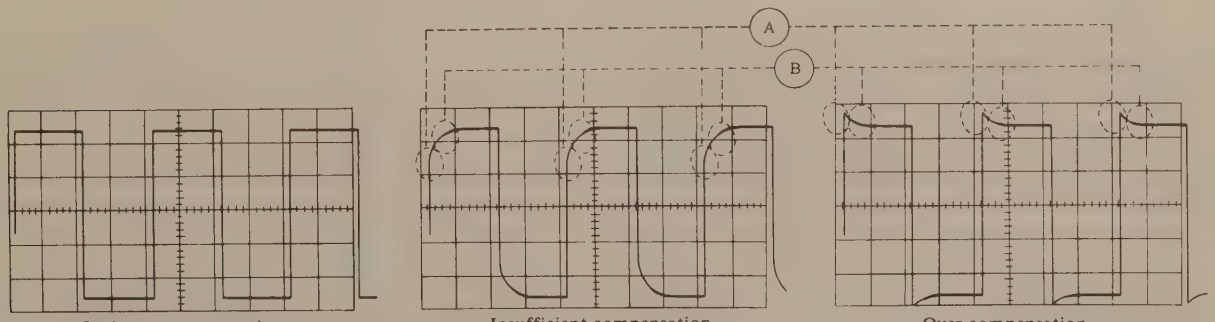


Figure 7–8 Calibration of VOLTS/CM Phase



(a) Instruments required
(1) Capacitance meter
(2) Square wave generator [1]

(b) Set the VOLTS/CM switches of CH1 and CH2 to the 10 mV position, and connect the capacitance meter to an INPUT.
CAUTION: Test voltage of the capacitance meter must not exceed the maximum rated input voltage of SS-212, 500 V (DC + AC peak). An excessive test voltage will damage the input circuit.

(c) Adjust trimmers C9A/B to obtain minimum and equal input capacitance in CH1 and CH2. The trimmers can be reached from the front panel as shown in Figure 7-7.

(d) Remove the capacitance meter from the input and connect the 10 : 1 probe instead.

(e) Terminate the square-wave generator output and feed the signal to the probe. Set the signal frequency to 1 kHz and adjust signal level to set the display amplitude to 5 cm

(f) Adjust the phase-compensating trimmer in the probe for the correct display as shown in Figure 7-8. In this adjustment, disregard the detailed adjustment for the waveform indicated by dotted lines (part A) in Figure 7-8.

(g) Rotate the VOLTS/CM switch to the 20 mV position. The display amplitude should also be 5 cm. Calibrate part A using C11A/B (refer to Figure 7-7, C11A for CH1 and CHB for CH2), and part B using C1A/B.

(h) Referring to Table 7-4, adjust the attenuator compensation at each position of the VOLTS/CM switch. Output level of the squarewave generator will become insufficient as the VOLTS/CM switch position is changed and consequently the display amplitude will decrease. Due to panel space, only the upper half of the trimmer number is marked on the panel for some compensation trimmers. In this case, the related trimmer is indicated by a black line on the panel.

15. Square-Wave Response at 5 mV Range and 10 mV Range

The instruments shown below are required for square-wave characteristics calibration in the 5 mV and 10 mV ranges. In addition, the vertical plug-in unit must be pulled out before calibrating C34A/B. Plug-in unit extension connector is required to connect the plug-in unit to the chassis. However, the plug-in unit extension connector must be used only for calibration of C34A/B described in steps (f) to (h). If other ranges are adjusted with the unit pulled out, the accuracy of calibration will be degraded when the unit is assembled in the main chassis.

Be sure to turn the power switch off before assembling or disassembling the unit or connecting the plug-in unit extension connector.

(a) Instruments required
Plug-in unit extension connector for vertical plug-in unit
Square-wave generator (II)

Rise time	20 nSEC or less
Output voltage	0 to 1 V
Repetition frequency	60 Hz to 1 MHz

Square-wave generator (III)

Rise time	500 pSEC or less
Output voltage	0 to 1 V

50-ohm coaxial cable
50-ohm termination (BB50M1 or equivalent)
50-ohm coaxial attenuator (AA series or equivalent. When the generator output is calibrated in the required range, the attenuator is not required.).

(b) Set the controls as shown below.

BAND WIDTH	FULL
VOLTS/CM (CH1, CH2)	10 mV
VARIABLE (CH1, CH2)	CALIB

(c) Connect the generator (II) output to the CH1 INPUT through the 50-ohm coaxial cable, coaxial attenuator and terminator. Change the MODE switch to the CH1 position.

(d) Set the generator frequency to 15 kHz, and adjust signal level to set the display amplitude to 4 cm. Position the display in the center of the viewing area.

(e) Adjust the A TIME/CM switch so two cycles of square-wave will be displayed.

(f) Adjust trimmer C34A to minimize waveform distortion (sag and rounding). The trimmers C34A/B are located between the VOLTS/CM switch S2A · S2B and printed-circuit board in the plug-in unit.

(g) Feed the signal to the CH2 INPUT, and change the MODE switch to the CH2 position. Adjust trimmer C34B to minimize the waveform distortion.

(h) Repeat steps (f) and (g) several times until displays of CH1 and CH2 become equal in waveform and minimum in distortion.

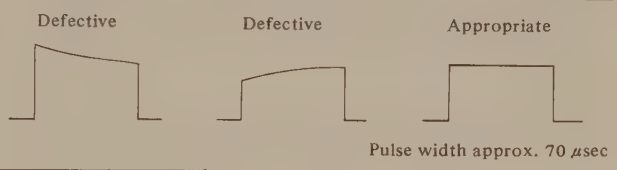
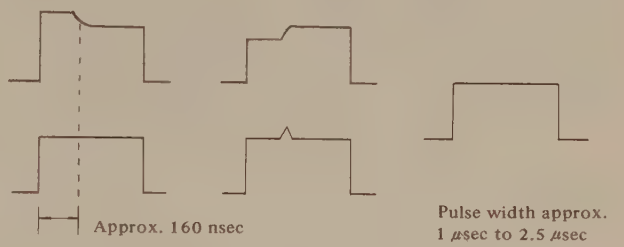
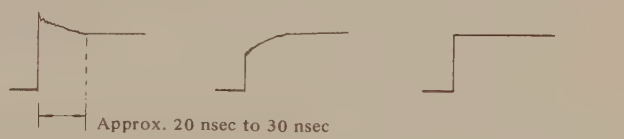
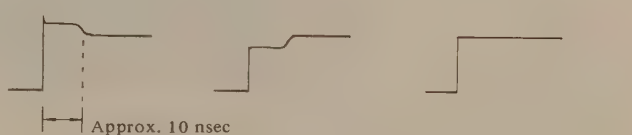
(i) Turn the power switch off, disconnect the plug-in unit extension connector and plug the unit into the chassis.
Adjust resistor R202 and coil L201 (refer to Figure 7-6), changing the oscillation frequency of rectangular signal generator (II) continuously from 250 kHz to 1 MHz, to reduce matching distortion caused by the delay line.

(j) Disconnect the square-wave generator (II) from the CH1 INPUT and connect generator (III) instead. Use the coaxial cable, coaxial attenuator and termination similar to the case above.

(k) Set the input pulse width to approximately 0.4 μsec and adjust the output level to set the display amplitude to 4 cm. Change the A TIME/CM switch to the 20 nSEC position. Position the display in the center of the viewing area. Adjust C205 and R205 (refer to Figure 7-6) to minimize waveform distortion.

(l) Change the TIME/CM switch to the 10 nSEC position, and adjust C49A/B, C50A/B, R50A/B, C244 and R244 (suffix A for CH1 and B for CH2, refer to Figure 7-6) to minimize distortion in the range 1 cm from the leading edge on the displayed waveform. Adjust C82A/B, C97A/B, C120A/B, C203, C224 and R224 (refer to Figure 7-6) to minimize distortion in the leading edge and adjacent part. Adjust R256 (refer to Figure 7-6) to minimize the matching distortion which will oppear delayed by about 10 nsec from the leading

Table 7–5 Square-wave characteristics

VOLTS/CM range	Measuring instruments	Adjustment sequence	Elements to be calibrated	Waveforms
10 mV	Square-wave generator[II] Rise time 20nsec or less	1	C30A/B (A for CH 1 and B for CH 2)	
		2	R202 L201	
	Square-wave generator[III] Rise time 500psec or less pulse width approx. 0.4 μsec	3	C205 R205	
		4	C49A/B C50A/B R50A/B C244 R244	
		5	C82A/B C97A/B C120A/B C203 C224 R224	
		6	R256	
5 mV		7	C79A/B R79A/B	

edge.

(m) Change the VOLTS/CM switch to the 5 mV position, and adjust the output level of generator (III) to set the display amplitude to 4 cm. Adjust C79A/B, R79A/B (refer to Figure 7-6) to minimize distortion in the leading edge and adjust part.

(n) The square-wave characteristics described in the above steps are illustrated in Table 7-5.

CAUTION: Calibration of the frequency characteristics must be performed after the square-wave characteristics are calibrated. When R245 is adjusted to calibrate the square-wave characteristics, the steps described in item 14, "Vertical deflection sensitivity" must be checked to confirm that the rated sensitivity is retained in the 5 mV and 10 mV ranges. If necessary, recalibrate the deflection sensitivity in these ranges.

16. Vertical Amplifier Bandwidth

After calibrating the square-wave characteristics the 5 mV and 10 mV ranges, frequency characteristics of the vertical-axis amplifier must be confirmed.

(a) Instruments required

Signal generator (refer to "Square-wave characteristics" for operation of the coaxial cable and termination.)

(b) Change the controls as indicated below.

VOLTS/CM (CH1, CH2)	10 mV
MODE	CH 1
A TIME/CM	1 mSEC

(c) Terminate the signal generator output, and feed the signal to the CH1 INPUT.

Set the signal frequency to 10 MHz and adjust the generator output level to set the display amplitude to 40 mm. The generator output level must be retained constant against changes in frequency.

(d) Change the signal frequency to 200 MHz. Display amplitude must be more than 28 mm (-3 dB).

(e) Repeat the same check for CH2.

(f) Change the VOLTS/CM switch to 5 mV range.

Set the signal frequency to 10 MHz, and the display amplitude to 40 mm by adjusting the signal output level. Retain the signal output level against change in oscillating frequency.

(g) Change the signal frequency to 100 MHz. Display amplitude should be larger than 28 mm (-3 dB). Repeat the same calibration for CH2.

(h) Frequency characteristics of the vertical axis in VOLTS/CM switch ranges above 20 mV should be within -4 dB at 200 MHz. For example, with the display amplitude set to 40 mm at 10 MHz, the amplitude should not be less than 25 mm (-4 dB) at 200 MHz. Repeat the check for CH2.

CAUTION: The frequency characteristics are closely correlated with the square-wave characteristics. If the frequency characteristics are poor, square-wave characteristic adjustment may be necessary.

17. Performance of Trigger Amplifier at High Frequency Level

(a) Instrument required

Signal generator (coaxial cable and termination, the same as used in section 16-(a): "square-wave characteristics".)

(b) Set the controls as follows.

HORIZ DISPLAY	A
A SWEEP MODE	AUTO
SLOPE (A)	+
COUPLING (A)	AC
SOURCE (A)	INT
A TIME/CM	10 mSEC
VOLTS/CM (CH1, CH2)	10 mV
MODE	CH 1

(c) Be sure to turn the power switch off before pulling out or plugging in the vertical axis plug-in unit.

(d) Set the generator frequency at 100 MHz, terminate the signal output, and feed the signal to the INPUT of CH1. Adjust the genrator output level to set the display amplitude to 3 cm.

(e) Trigger the sweep. If triggering is not stable at high frequencies, adjust the capacitance of three trimmers C149A, C160A and C172A (refer to Figure 7-9).

These trimmers must be adjusted after the plug-in unit is removed. Be sure to turn the power switch off whenever the plug-in unit is pulled out.

Plug in the unit and check the result of the capacitance adjustment, using the LEVEL (A) and HF STABILITY controls to make the triggering stable.

(f) Change the MODE switch to the CH2 position. Connect the signal generator to the CH2 INPUT, and adjust trimmers C149B, C160B and C172B (refer to Figure 7-9) similar to the CH1 adjustment.

CAUTION: The adjustment of trimmers C149A/B, C160A/B and C172A/B requires considerable skill, since the results cannot be displayed directly until the plug-in unit is installed in position. These trimmers also affect the high-frequency triggering performance, and the circuit may start oscillation when it is connected in cascade to CH2.

18. DC Balance and Zero Level of Trigger Amplifier Output

Prior to calibrating the trigger amplifier output, calibration of the STEP ATTEN BAL and VARIABLE BAL controls must be completed for both CH1 and CH2.

(a) Instruments required
Sine-wave generator
DC voltmeter [3]

(b) Turn the power switch off, and pull out the vertical axis plug-in unit. Connect the unit to the main chassis through the plug-in unit extension connector. Observe the precaution on handling of the power switch before and after plugging in and pulling out the unit.

(c) Change the control settings as indicated below.

HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
COUPLING (B)	DC
MODE	CH 2
VOLTS/CM (CH2)	10 mV
AC-GND-DC (CH2)	GND

(d) Measure the potential difference between the collectors of TR179 and TR180 with a DC voltmeter [3] and adjust the variable resistor, CH2 DC BAL R163B, (refer to Figure 7-9) for 0 volts.

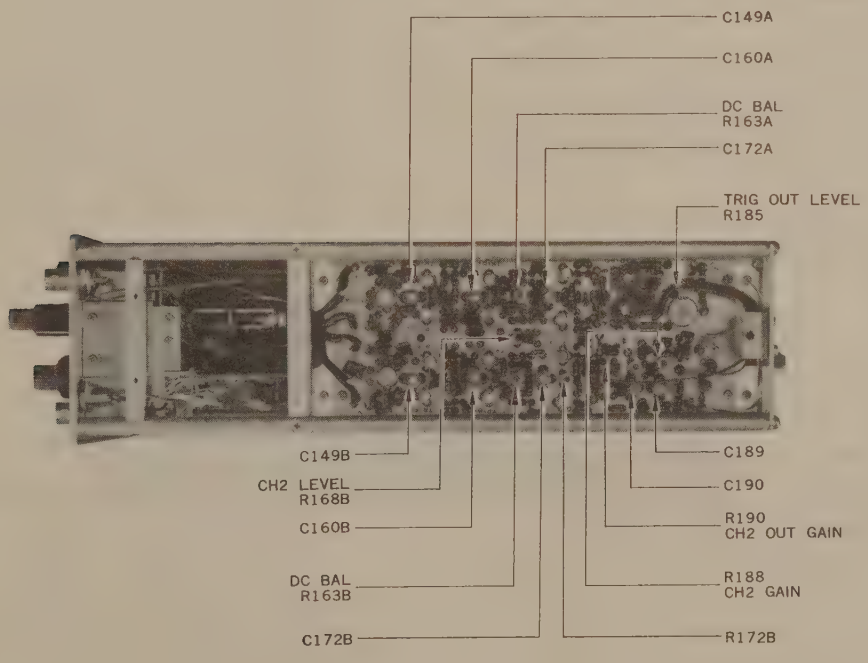
(e) Set the MODE switch to the CH1 position, and similarly adjust the variable resistor, CH1 DC BAL R163A, (refer to Figure 7-9) in the same manner as in adjustment (d) until the potential difference between the collectors of TR179 and TR180 reaches zero volts.

(f) Next, adjust the resistor, TRIG OUT LEVEL R185, (refer to Figure 7-9) until the voltage between the collector of TR179 and ground becomes zero.

(g) Change the MODE switch to the CH2 position and adjust the CH2 LEVEL resistor, R168B (refer to Figure 7-9) until the voltage between the collector of TR179 and ground becomes zero in the manner similar to that described in adjustment (f).

(h) Disconnect the plug-in unit connector.

Figure 7–9 Vertical Amplifier Unit (Trigger Amplifier on the Right View)



19. Zero Level of CH2 Amplifier Output

Prior to calibrating the CH2 OUT zero level, calibration of the trigger amplifier DC balance and zero level must be completed.

(a) Change the control settings as follows.

HORIZ DISPLAY	A
MODE	CH 1
VOLTS/CM (CH1)	5 mV
AC-GND-DC (CH1)	GND

Position the trace in the center of the viewing area with the CH1 POSITION control.

(b) Change the control settings as indicated below.

MODE	CH 2
AC-GND-DC (CH2)	GND

Similarly position the trace in the center of the viewing area using the CH2 POSITION control.

(c) Change the MODE to the CH1 position, AC-GND-DC (CH1) to DC position and connect the CH2 OUT and CH1 INPUT through a coaxial cable.

(d) Adjust the CH2 OUT LEVEL R199 control (refer to Figure 7-6) until the trace is correctly positioned in the center of the graticule.

20. Sensitivity in Cascade Connection

(a) Instrument required

Sine-wave generator (output level accuracy must be calibrated to within 0.5% at 1 kHz.)

(b) Pull out the vertical axis plug-in amplifier and connect the plug-in unit extension connector. Observe the precaution on handling the plug-in unit extension connector.

(c) Change the control settings as shown below.

VOLTS/CM (CH1, CH2)	5 mV
VARIABLE (CH1, CH2)	CALIB
AC-GND-DC (CH1, CH2)	DC
MODE	CH 1

(d) Connect the CH1 INPUT and CH2 OUT through a coaxial connector.

(e) Set the sine wave generator frequency to 1 kHz and signal level to 4 mV p-p. Supply in the signal to the CH2 INPUT.

(f) Trigger the sweep and adjust the CH2 OUT GAIN R192 control to set the display amplitude to 4 cm. (Refer to Figure 7-9)

(g) Disconnect the plug-in unit extension connector.

21. SQUARE-WAVE Response and Bandwidth in Cascade Connection

(a) Instruments required

Square-wave generator (IV)

Rise time	3 nSEC or less
Output voltage	0 to 1 V
Repetition frequency	400 kHz to 1 MHz

Signal generator
50-ohm coaxial cable
50-ohm Termination (BB50M1 or equivalent)
50-ohm coaxial attenuator (AA series or equivalent)

(b) Pull out the vertical plug-in unit and connect the plug-in unit extension connector to it. Observe the precaution on handling the plug-in unit extension connector.

(c) Connect the square-wave generator (IV) output to the CH2 INPUT through a coaxial cable, 50-ohm coaxial attenuator and a 50-ohm termination.

Set signal frequency to 1 MHz (pulse width 0.5 μSEC).

(d) Change the control setting and connect CH1 INPUT to CH2 OUTPUT as described in steps (c) and (d) in item 21 above.

(e) Change the A TIME/CM switch to the 0.1 μSEC, and trigger the sweep. Adjust the generator output to set the display amplitude to 4 cm (use the generator level control or the coacial attenuator).

(f) Adjust R190 and C190 (refer to Figure 7-9) to minimize the distortion of the displayed square waveform.

When using a square-wave generator whose rise time is 3 nSEC, overshoot and ringing must be reduced to 10% or less.

(g) Change the A TIME/CM switch to the 1 mSEC position.

(h) Disconnect the plug-in unit extension connector, and plug-in the vertical plug-in unit.

(i) Terminate the signal generator output and feed the signal to the CH2 INPUT. Set the generator frequency to 100 kHz, and adjust the signal level to set the display amplitude to 40 mm The signal voltage must be constant against the changes in frequency.

(j) Change the frequency to 50 MHz. The display amplitude must be 28 mm or larger (-3 dB).

22. Trigger Level Center of A Trigger

(a) Instrument required
Sine-wave generator

(b) Change the controls as indicated below.

HORIZ DISPLAY	A
SOURCE (A, B)	INT
COUPLING (A, B)	AC
A-SWEEP MODE	AUTO
A, B TIME/CM	.5 mSEC

(c) Set the sine-wave generator frequency to 1 kHz, feed the signal to the INPUT, and set the display amplitude to 5 mm

(d) Set the LEVEL (A) control to the mid-range, and trigger the sweep. Adjust the LEVEL CENTER adjustment R310 (refer to Figure 7-10) so that the sweep in the + slope and in the - slope are

symmetrical when the SLOPE switch (A) is switched from + to -.

23. Trigger Level Center of B Trigger

(a) Instruments required
Signal generator
Plug-in unit extension connector (for horizontal plug-in)

(b) Change the controls as shown below.

HORIZ DISPLAY	DEL'D (B)
DLY'D (B) MODE	TRIG'D
DELAY TIME MULTI dial	1.00

Refer to "A-trigger level center" for setting other controls.

(c) Set the display amplitude to 5 mm. Set the LEVEL (B) control to mid-range, and trigger the sweep.
Adjust the LEVEL CENTER adjustment R526 (refer to Figure 7-11), so that the sweeps from the + slope and the − slope are symmetrical when the SLOPE switch (B) is switched from + to -.

24. A Position and MAG CENTER

Starting position of sweep A and the magnified position interact, therefore this calibration must be repeated alternately.

(a) Use a plug-in unit extension connector (for horizontal plug-in).

(b) Change controls to positions indicated.

HORIZ DISPLAY	A
A TIME/CM	1 mSEC
MAG	X1

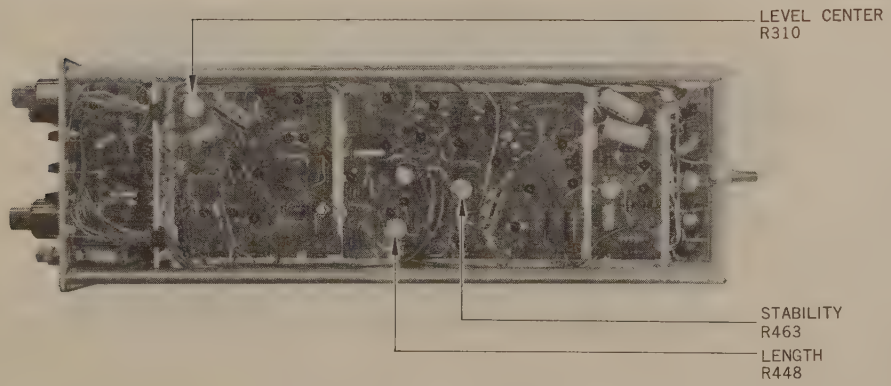
(c) Use the calibration voltage as an input signal. Trigger the sweep and adjust the horizontal POSITION so that the starting point of the sweep coincides with the centerline of the graticule.

(d) Change the MAG switch to the X10 position to magnify the sweep input signal. Adjust the MAG CENTER adjustment R713 (refer to Figure 7-12) to vary the starting point of the magnified sweep to the centerline.

(e) If R713 is rotated, the starting point of the X1 sweep also shifts, therefore, bring it to the centerline again by adjusting the A POSITION adjustment R722 (refer to Figure 7-12).

(f) By repeating the procedures in steps (d) and (e) two or three times, the sweep will be magnified at the center of the graticule in both the X1 and X10 modes.

Figure 7–10 Horizontal Plug-in Unit (Bottom View)



25. A-Sweep Time, Wide Sweep Width by Use of MAG Switch and Liniarity in High-Speed Sweep

(a) Instruments required
Time-marker generator
Signal generator
Outputs of these generators must be terminated by a 50-ohm termination (BBM1 or equivalent)

(b) In these calibration steps, the plug-in unit extension connector for the horizontal axis plug-in unit must be used when required. The plug-in unit extension connector must not be used for calibration of high-speed sweep operation.

(c) Change the control settings as follows.

HORIZ DISPLAY	A
A TIME/CM	1 mSEC
A VARIABLE	CALIB
MAG	X1

(d) Set the A SWEEP CAL R486 (refer to Figure 7-11) to the mechanical center position.

(e) Feed in a 1 mSEC signal from the time-marker generator to the INPUT, and trigger the sweep. Adjust the SWEEP CAL, R759 (refer to Figure 7-5) so that each marker signal is aligned with vertical graduations of the graticule.

(f) Change the marker period to 100 μSEC, and change the MAG switch to the X10 position. Align the markers with the vertical graduation by adjusting the MAG GAIN, R718 (refer to Figure 7-12).

(g) Return the MAG switch to the X1 position.

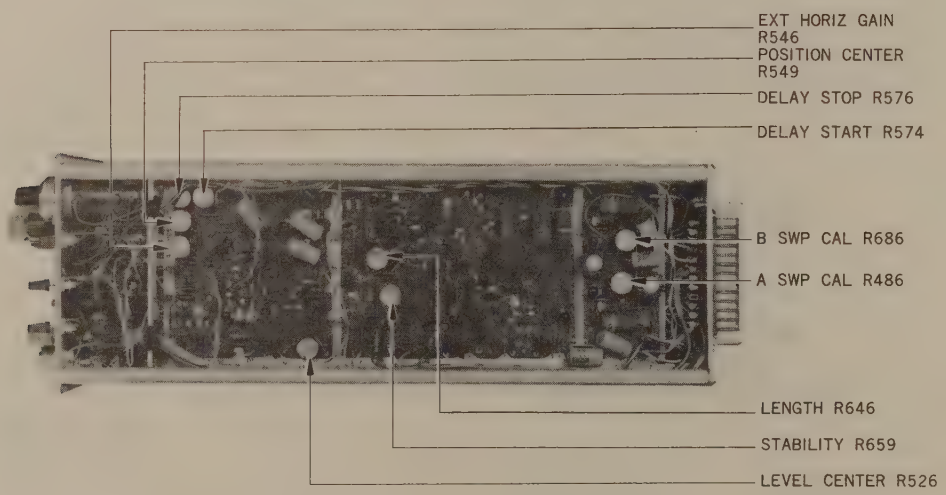
(h) Change the A TIME/CM switch to the 50 nSEC position and the marker period to 0.1 μSEC, and adjust C498A (refer to Figure 7-5) so that the marker signals will appear at two-division intervals. Again change the A TIME/CM switch to the 0.1 μSEC position and the marker period to 0.1 μSEC. Adjust C499A (refer to Figure 7-5) to align the marker to each vertical graduation. Similarly adjust C499C (refer to Figure 7-5) after the A TIME/CM switch is changed to the 1 μSEC position.

(i) Next, linearity of the high-speed sweep must be calibrated. Disconnec the plug-in unit extension connector and replace the plug-in unit in the main chassis. Remove the time marker generator from the INPUT, and connect the signal generator to the INPUT.

Set the generator frequency to 100 MHz and change the A TIME/CM switch to the 10 nSEC position.

(j) Adjust C403 (refer to Figure 7-5), C700 (refer to Figure 7-12), C753 (refer to Figure 7-5), C754 (refer to Figure 7-5), R758 and C751 (refer to Figure 7-5) so that the alternately displayed waveform coincides with the vertical graduation as closely as possible (one signal

Figure 7–11 Horizontal Plug-in Unit (Top View)



per division). Change the MAG switch to the X10 position and switch the A TIME/CM to 20 nSEC and 50 nSEC sequentially (sweep speed on the viewing area becomes 2 nSEC and 5 nSEC, respectively). Readjust C753 and C754 to improve the linearity. Change the A TIME/CM switch to the 10 nSEC position and the MAG to the X10 position. Adjust C706 (refer to Figure 7-12) to set sweep speed correctly to 1 nSEC/cm.

(k) The controls mentioned in step (j) above interact, therefore, these adjustments will have to be repeated.

(l) Check the sweep speed and the linearity for all TIME/CM ranges using the time-marker generator and signal generator. Frequency accuracy of these generators should be sufficiently higher than the allowable accuracy for sweep speed.

NOTE: The sweep speed calibration described in this item will influence the B-sweep performance which will be described next.

26. B-Sweep Time, and Linearity in High-Speed Sweep

Prior to calibrating B-sweep time, calibration of A sweep, magnified sweep and sweep linearity at high-speed must be completed as described above.

(a) Instruments required

Refer to item 26 above for required instruments and precaution on use of plug-in unit extension connector for horizontal axis plug-in unit.

(b) Change the control settings as follows.

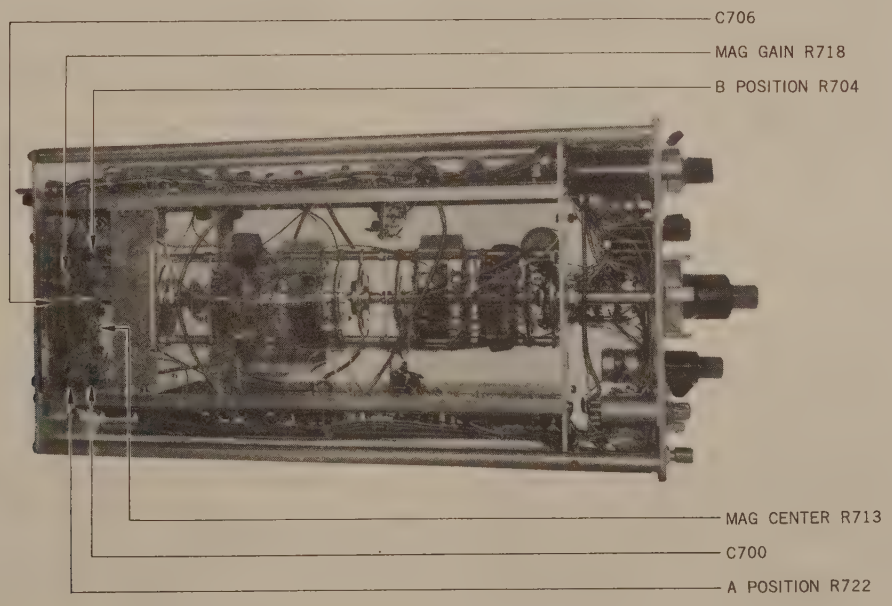
HORIZ DISPLAY	DLY'D (B)
A, B TIME/CM	1 mSEC
A and B VARIABLE	CALIB
MAG	X1
DELAY TIME MULTI dial	1.00

(c) Set the time-marker to 1 mSEC, feed the signal to the INPUT and trigger the sweep.

Adjust the B SWEEP CAL, R686 (refer to Figure 7-11) to align the displayed marker signals on the vertical graduations.

(d) Change the A TIME/CM switch to 1 μSEC, B TIME/CM to 50 nSEC. (NOTE: The UNCALIB neon lamp will light when the A TIME/CM switch is set to ranges faster than 1 μSEC, although it has no relation to accuracy of the B-sweep time.) Change the time-marker generator to 0.1 μSEC, and adjust C698A (refer to Figure 7-5) to align markers at two cm intervals. Change the B TIME/CM to the 0.1 μSEC position and the marker frequency to 0.1 μSEC. Adjust C699A (refer to Figure 7-5) to position marker signals at 1 cm intervals. Change the B TIME/CM

Figure 7—12 Horizontal Plug-in Unit (Rear View)



switch to the 1 μSEC position, and adjust C699C (refer to Figure 7-5) in the same way.

(e) Next, linearity of the high-speed sweep must be calibrated. Disconnect the time-marker generator from the INPUT and connect a signal generator instead.

Set the generator frequency to 100 MHz and the B TIME/CM switch to the 10 nSEC position.

(f) Adjust C607 (refer to Figure 7-5) and C612 (refer to Figure 7-5) alternately to equalize the displayed marker intervals as much as possible (one cycle in one division). Change the MAG switch to the X10 position.

Switch the B TIME/CM to 20 nSEC and 50 nSEC alternately (sweep speed on the graticule becomes 2 nSEC/cm and 5 nSEC/cm respectively), and adjust C607 and C612 to improve sweep linearity as much as possible.

Repeat calibration steps in step (f) several times.

(g) Disconnect the plug-in unit extension connector and place the unit in position. Check sweep speed and linearity of all B TIME/CM switch ranges using the time marker and signal generators. Accuracy of these generators must be sufficiently higher than allowable accuracy of the sweep speed.

27. DELAY TIME Multiplier Dial

The DELAY TIME MULTI dial is calibrated after the calibration of A and B sweep time is completed.

(a) Pull out the unit and connect to the main chassis using the plug-in unit extension connector for the horizontal plug-in unit.

(b) Change the control setting as follows.

HORIZ DISPLAY	A INTEN BY B
A TIME/CM	1 mSEC
B TIME/CM	.1 mSEC
A and B VARIABLE	CALIB
MAG	X1
A SWEEP MODE	AUTO
DLY'D (B) MODE	AUTO

(c) Rotate horizontal position control so that starting point of A sweep is positioned the left end of the display.

Set the DELAY TIME MULTI dial to 1.00, and adjust the DELAY START, R574 (refer to Figure 7-11) so that the intensity-modulated B-sweep part starts from the starting point of the second pulse.

(d) Set the DELAY TIME MULTI dial to the 9.00 position and adjust the DELAY STOP, R576 (refer to Figure 7-13) so that the B-sweep starts from the starting point of the 10th pulse of the A-sweep.

(e) Repeat steps (c) and (d) several times.

28. Sweep Length

Calibration of the trace length should be performed after both sweep time and delay time multi dial calibrations have been completed.

(a) Pull out the unit and connect the unit to the main chassis through the plug-in unit extension connector. (for horizontal plug-in)

(b) Control settings are identical to those for the DELAY TIME MULTI dial above.

(c) Set the DELAY TIME MULTI dial to 1.00. Adjust the horizontal POSITION control to align the starting point of intensity-modulated B-sweep LENGTH adjustment R448 (refer to Figure 7-10) so that the trace will end correctly at the rightmost vertical scale. The sweep length is calibrated to 11 cm.

(d) Change the HORIZ DISPLAY switch to the DEY'D (B) position, and adjust the B-sweep LENGTH R646 (refer to Figure 7-11) so that the trace will end at the rightmost vertical scale.

29. Stability of SWEEP A and SWEEP B

The calibration of A and B sweep stability is essential for correct single sweep and triggering operations.

(a) Instrument required

Sine-wave generator

(b) Pull out the unit and connect it to the main chassis with the plug-in unit extension connector for the horizontal plug-in unit.

Figure 7–13 (a) Start ADJ

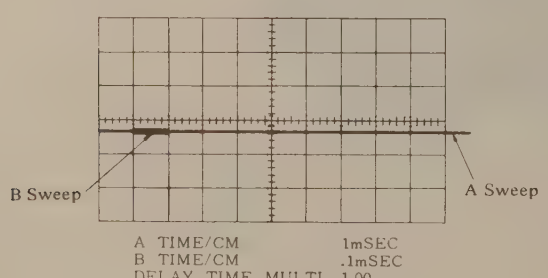
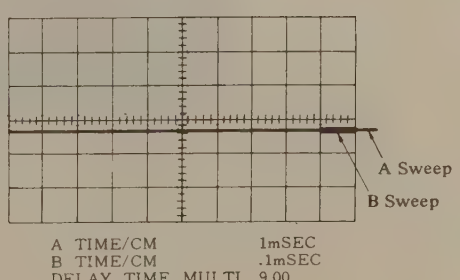


Figure 7–13 (b) STOP ADJ



(c) Change control positions as shown below.

HORIZ DISPLAY	A
A SWEEP MODE	AUTO
COUPLING (A and B)	AC
SOURCE (A and B)	INT
A and B TIME/CM	1 mSEC

(d) Set the sine wave generator frequency to 1 kHz, feed the signal to the INPUT and set the display amplitude to 1 cm

(e) Adjust the LEVEL (A) control to trigger the sweep. Change the A SWEEP MODE to the SINGLE position, and adjust the A-sweep STABILITY R463 (refer to Figure 7-10) so that the sweep circuit will be activated only once when the RESET button is depressed. Observation of the trace will be facilitated by rotating the INTENSITY control fully clockwise.

(f) Change the control settings as shown below.

HORIZ DISPLAY	A INTEN BY B
A SWEEP MODE	AUTO
DLY'D (B) MODE	TRIG'D
B TIME/CM	.1 mSEC

(g) Set the DELAY TIME MULTI dial to 1.00, and adjust the LEVEL (B) so that the intensity-modulated part will start from the second vertical scale.

Adjust the B-sweep STABILITY, R659 (refer to Figure 7-11), until the intensified part jumps the vertical scales when the DELAY TIME MULTI dial is turned clockwise (the intensified B-sweep must not move continuously on the display).

30. Spot Position in EXT HORIZ

Prior to calibrating the spot position, the calibration of A POSITION and MAG CENTER must have been completed.

(a) Pull out the unit and connect it to the main chassis with the plug-in unit extension connector.

(b) Change the HORIZ DISPLAY switch to the A position, and adjust the horizontal POSITION to align the starting point of the sweep to the leftmost vertical scale of the graticule. Change the HORIZ DISPLAY to the EXT HORIZ position, and adjust the POSITION CENTER adjustment, R549 (refer to Figure 7-11) so that the spot will be correctly positioned in the center of the graticule.

31. EXT HORIZ Sensitivity

Prior to starting calibration of the EXT HORIZ sensitivity, the calibration of vertical deflection sensitivity, sweep time and sweep magnification must have been completed.

(a) Instrument required

Sine-wave generator (output level accuracy must be calibrated to within 0.5% at 1 kHz.)

(b) Pull out the unit and connect it to the main chassis with the plug-in unit extension connector.

(c) Change the controls as shown below.

MODE	CH 1
VOLTS/CM (CH2)	5 mV
HORIZ DISPLAY	EXT HORIZ
SOURCE (B)	INT
COUPLING (B)	DC

(d) Connect a sine-wave generator to the CH2 INPUT, set the signal frequency to 1 kHz and adjust the signal level to 20 mV p-p.

(e) Adjust the EXT HORIZ GAIN, R546 (refer to Figure 7-11), to set the display amplitude correctly to 40 mm.

32. Square-Wave Response and Bandwidth of External Signal Injected into Input TRIG OR HORIZ INPUT

(a) Instrument required

Signal generator (terminated by a 50-ohm terminator, BBM1 or its equivalent)

(b) Change control settings as shown below.

HORIZ DISPLAY	EXT HORIZ
COUPLING (B)	DC
SOURCE (B)	EXT ÷ 10

(c) Set the CALIBRATOR VOLT switch to the 2 V position, and connect the CAL OUT to the TRIG OR HORIZ INPUT through a coaxial cable. Two spots should be displayed horizontally at tan interval of 20 mm (16 to 24 mm). Adjust C502 (refer to Figure 7-5) so that only two sharp spots will be displayed without a trace inside or outside of the spots. This calibration will be facilitated by increasing the spot intensity.

(d) Change the source (B) switch to the EXT position. Disconnect the CAL OUT from the TRIG OR HORIZ INPUT, and connect a signal generator to the INPUT. Set the signal frequency to 50 kHz, and adjust the signal level to set the display amplitude horizontally, to 40 mm. Retain the signal level constant against changes in frequency. Change the frequency to 1 MHz. The display amplitude must be larger than 28 mm (-3 dB).

33. CALIBRATOR Output Repetition Frequency

(a) Instrument required

Time-marker generator (terminated by a 50-ohm terminator).

(b) Change the control settings as follows.

MODE	CH 1
AC-GND-DC	DC
HORIZ DISPLAY	A
A TIME/CM	.5 mSEC

(c) Set the time-marker frequency to 1 mSEC, connect the signal to the CH1 INPUT, and trigger the display.

(d) Adjust the A TIME/CM VARIABLE so that marker signals will be displayed at 1 cm intervals. Adjust the horizontal POSITION control to start the first marker from the leftmost vertical scale, and readjust the A TIME/CM VARIABLE control to align the 11th pulse to the rightmost vertical scale of graticule.

(e) Disconnect the time marker from the INPUT and connect the CH1 INPUT to the CAL OUT with a coaxial cable.

(f) Adjust the top ferrite core of T1100 (refer to Figure 7-2) so that 10 cycles of the CALIBRATOR voltage will start from and end at, the leftmost and rightmost vertical scales.

34. CALIBRATOR VOLTS Accuracy

(a) Instrument required

Sine-wave generator (output level accuracy must be calibrated to within 0.5% at 1 kHz).

(b) Change the control settings as indicated below.

MODE	CH 1
VOLTS/CM	5 V
VARIABLE	CALIB
AC-GND-DC	DC
HORIZ DISPLAY	A
A TIME/CM	10 mSEC
CALIBRATOR VOLTS	10

(c) Set the sine wave generator frequency to 1 kHz and 10 Vp-p in output amplitude. Connect the signal to the CH1 INPUT, and sweep the display. Read amplitude of the display accurately.

(d) Remove the sine wave generator from the input, and connect the CAL OUT to the CH1 input. Adjust the CAL ADJ R1102 (refer to Figure 7-2) so that the display amplitude agrees with the recorded value.

(e) Check accuracy of CALIBRATOR VOLTS switch positions comparing the display amplitude of the CAL OUT voltage to that obtained from the sine wave generator.

35. Adjustment of Probe

Prior to calibrating the probe, the VOLTS/CM 10 mV and 5 mV ranges must have been calibrated for square wave-characteristics, and a check of the vertical axis frequency response must also be completed.

(a) Instruments required

Signal generator

Square-wave generator (111)

Rise time	500 pSEC or less
Output voltage	0 to 1 V peak to peak

50-ohm coaxial cable

50-ohm termination (BB50M1 or equivalent)

BNC-J adapter

50-ohm coaxial attenuator (AA series or its equivalent, when the square-wave generator output level is calibrated in the required range, the coaxial attenuator is not required.)

(b) The probe phase must be calibrated first. Remove the arrow contact from the probe tip, and connect the 1018 probe between the INPUT and CAL OUT. Set the VOLTS/CM and the CALIBRATOR VOLTAGE switch to the 10 mV and .5 position, respectively. Set the display amplitude to 5 cm Adjust the probe phase compensation trimmer in Figure 3-6 (refer to

Figure 7—14 Probe Phase

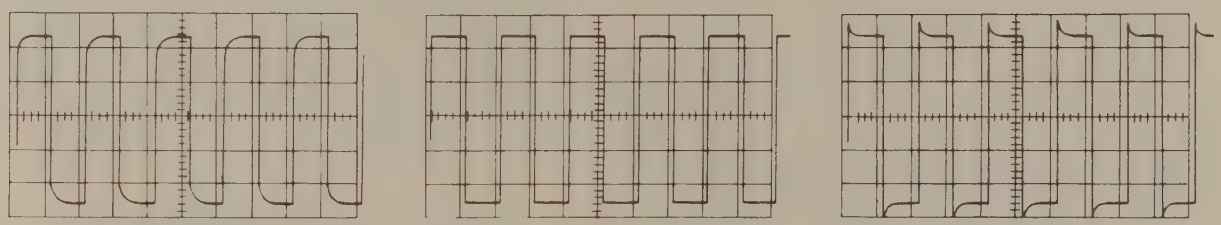
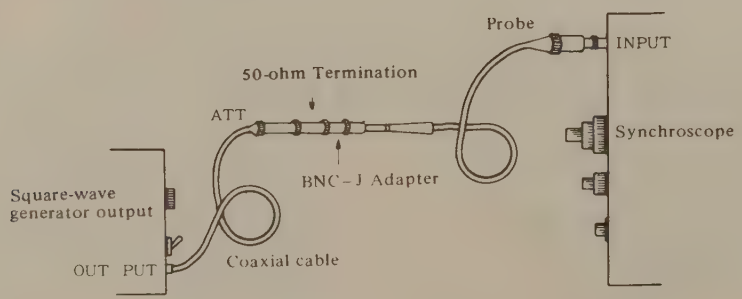


Figure 7—15 Connection of Probe



Chapter 3) for waveform flatness as shown in Figure 7-14.

(c) Adjustment of high-frequency compensation circuit follows. Loosen the screw on the phase calibration box cover, and shift the cover rearward. The adjustment set-up is shown in Figure 7-15.

(d) Change the VOLTS/CM switch to the 10 mV position and set the VARIABLE control to the CALIB position.

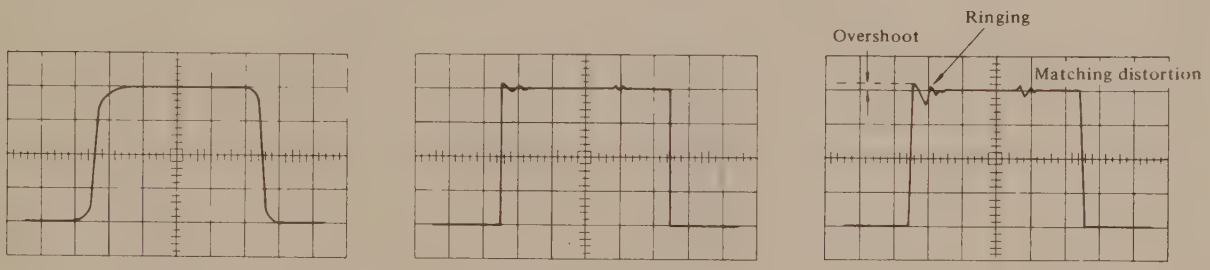
Although it is a function of repetition frequency and pulse width of the square-wave generator, the A TIME/CM switch is ordinarily set to the 10 nSEC position. Adjust the generator output to set the display amplitude to 4 to 5 cm. If the generator output cannot be controlled, use a 50-ohm coaxial attenuator to attenuate the signal level. The BNC-J adaptor is advantageous in securing the probe tip directly to the instrument, but it is not always necessary.

(e) Adjust R-2 (refer to Figure 7-17) to make the waveform top as flat as possible as shown in Figure 7-16(b), and adjust R3 and R4 to sharpen the front edge of the waveform. Also minimize the overshoot, undershoot ringing and matching distortion caused by mismatching of probe cable impedance (refer to Figure 7-16(c)). Repeat adjustment of R2, R3 and R4 to obtain optimum flatness and rising characteristics. To minimize the influence of induction during the adjustment, use an insulated screwdriver for trimmers and variable resistors.

(f) Frequency response of probe must be checked. Disconnect the square-wave generator, and connect a signal generator. The set-up is identical to that for the square-wave characteristics check.

(g) Change the A TIME/CM switch to the 1 mSEC position, set the generator frequency to 10 MHz, and set the display amplitude to 40 mm by adjusting the generator output level. Retain the output level con-

Figure 7–16 Square-wave Characteristics in High-frequency



(a) Leading edge is rounded. (b) Correctly adjusted waveform (c) Distortion in waveform

Figure 7–17 (a) Probe High-frequency Compensation Circuit 1

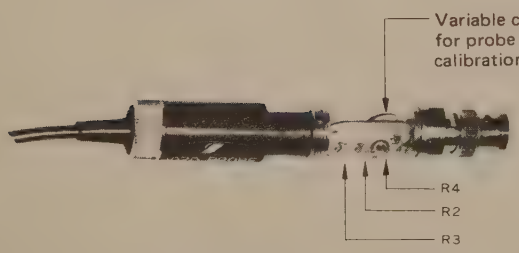
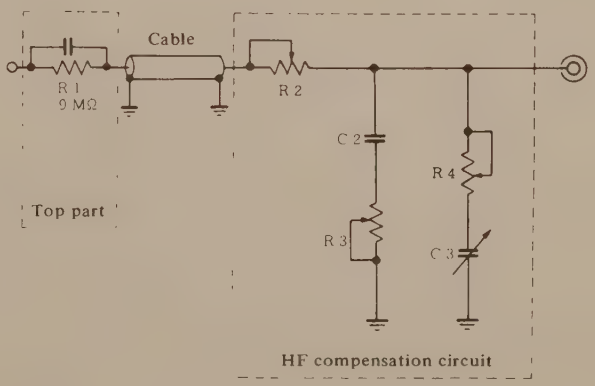


Figure 7–17 (b) Probe High-frequency Compensation Circuit 2



stant against changes in generator frequency.

(h) Change the generator frequency to 200 MHz. The display amplitude must be greater than 28 mm (-3 dB). This rating applies to probe model 1018 only. If the display amplitude is smaller than 28 mm at 200 MHz, R2, R3 and R4 must be recalibrated.

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ORDERING INFORMATION

Replacement parts may be ordered through an IWATSU Representative or directly from the factory. To be certain of receiving the proper parts, always include the following information with the order:

a. Model Number and serial number of the instrument on which the parts will be installed.

b. Circuit reference number and subassembly name, if applicable, for which the part is intended. If the part does not have a circuit reference, the description from the parts list should be used.

c. Iwatsu part number.

For factory repair, contact the IWATSU agent and include the following information:

a. Model number and serial number of the instrument on which the work is to be performed.

b. Details concerning the nature of the malfunction; or, type of repair desired.

Shipping instructions will be sent to you promptly.

HOW TO USE THIS PARTS LIST

The parts list is divided into subsections corresponding to the schematic diagrams such as VERTICAL AMP, TRIG CIRCUIT, SWEEP GENERATOR, HORIZONTAL AMP, CRT CIRCUIT and POWER SUPPLY. Component locations can be determined from the schematic diagrams, each component appears only once in the parts list. At the beginning of each subsection are listed part numbers for any complete subassemblies in that category that are available as replacement parts. These subassemblies may include individually-listed components; care should be taken to locate malfunctions to the lowest possible level of replacement part and thus avoid the time and cost involved in "over-repair"

ABBREVIATIONS

Cap ..... Capacitor
Res ..... Resistor
pap ..... paper
cer ..... ceramic
elect ..... electrolytic
var ..... variable
FET ..... field effect transistor

VERTICAL INPUT & ATTENUATOR

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C1 A/B	Cap., cer, var, 4 pF	74110-0900
C2 A/B	Same as C1	
C3 A/B	Same as C1	
C4 A/B	Same as C1	
C5 A/B	Same as C1	
C6 A/B	Same as C1	
C7 A/B	Same as C1	
C8 A/B	Same as C1	
C9 A/B	Same as C1	
C10 A/B	Cap., poly, 0.047 μF	74130-3310
C11 A/B	Cap., poly, var, 4 pF	74110-0300
C12 A/B	Same as C11	
C13 A/B	Cap., var, 1.5 pF	74110-0290
C14 A/B	Same as C13	
C15 A/B	Same as C13	
C16 A/B	Same as C13	
C17 A/B	Same as C13	
C18 A/B	Same as C13	
C20 A/B	Cap., cer, 7 pF, 50 V	74050-5510
C21 A/B	Cap., cer, 5 pF	74050-5140
C23 A/B	Cap., mica, 2 pF ±1 %	74090-5190
C24 A/B	Cap., mica, 20 pF ±10 %	74090-5010
C25 A/B	Cap., mica, 50 pF ±10 %	74090-5020
C26 A/B	Cap., mica, 100 pF ±10 %	74090-5030
C27 A/B	Cap., mica, 200 pF ±10 %	74090-5040
C28 A/B	Cap., mica, 500 pF ±10 %	74090-5050
C29A	Cap., cer, 1 pF	74050-4770
C30A	Same as C29A	
C31 A/B	Cap., 1 pF, 50 V	74060-4560
C32 A/B	Same as C31	
C33 A/B	Cap., cer, 4 pF	74050-4720
C34 A/B	Cap., cer, 20 pF	74110-0780
C35 A/B	Cap., cer, 30 pF, 500 V	74050-1780
L2A	Inductor FS-24974 ② coil D	74400-3980
L2B	Inductor FS-24974 ② coil C	74400-3970
L3A	Ferrite L-RH03 x 03 x 01	74560-1240
L6 A/B	Inductor FS-24974 ② coil F	74400-4940
L7 A/B	Same as L3A	
L10A	Inductor FS-24974 ② coil E	74400-4950
L10B	Same as L2A	
L11 A/B	Same as L3A	
L14 A/B	Same as L2B	
L18A	Same as L3A	
L19B	Same as L3A	
L20B	Same as L3A	
L22 A/B	Same as L3A	
L26 A/B	Same as L3A	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
L30 A/B	Same as L3A	
R1 A/B	Res., 47, 1/4 W, 5 %	74253-0070
R2 A/B	Res., 500 k, 1/4 W, 1 %	74226-0080
R3 A/B	Res., 1 M, 1/4 W, 1 %	74226-0150
R4 A/B	Res., 91, 1/8 W, 5 %	74257-0870
R5 A/B	Res., 82, 1/4 W, 5 %	74253-0810
R6 A/B	Res., 800 k, 1/4 W, 1 %	74226-0090
R7 A/B	Res., 250 k, 1/4 W, 1 %	74226-0070
R8 A/B	Same as R4	
R10 A/B	Res., 900 k, 1/4 W, 1 %	74226-0100
R11 A/B	Res., 111k, 1/4 W, 1 %	74226-0060
R12 A/B	Same as R4	
R13 A	Res., 47, 1/8 W, 5 %	74257-0140
R13 B	Res., 36, 1/8 W, 5 %	74257-1080
R14 A/B	Res., 950 k, 1/4 W, 1 %	74226-0110
R15 A/B	Res., 52.6 k, 1/4 W, 1 %	74226-0050
R16 A/B	Same as R4	
R17 A/B	Same as R13 A	
R18 A/B	Res., 980 k, 1/4 W, 1 %	74226-0130
R19 A/B	Res., 20.4 k, 1/4 W, 1 %	74226-0040
R20 A/B	Same as R4	
R21A	Res., 30, 1/8 W, 5 %	74257-0840
R21B	Res., 33, 1/8 W, 5 %	74257-0850
R22 A/B	Res., 990 k, 1/4 W, 1 %	74226-0130
R23 A/B	Res., 10.1 k, 1/4 W, 1 %	74226-0030
R24 A/B	Same as R4	
R25A	Res., 51, 1/8 W, 5 %	74257-0900
R25B	Res., 39, 1/8 W, 5 %	74257-0860
R26 A/B	Res., 995 k, 1/4 W, 1 %	74226-0140
R27 A/B	Res., 5.03 k, 1/4 W, 1 %	74226-0020
R28 A/B	Same as R4	
R29A	Same as R21B	
R29B	Same as R25B	
R30 A/B	Res., 998 k, 1/4 W, 1 %	74226-1790
R31 A/B	Res., 2 k, 1/4 W, 1 %	74226-2190
R32 A/B	Same as R4	74257-0140
R33 A	Same as R13A	74257-0140
R33 B	Same as R21B	74257-0850
R34 A/B	Res., 10, 1/4 W, 5 %	74253-0440
R35 A/B	Res., 100 k, 1/4 W, 1 %	74226-2020
R36 A/B	Same as R10	74226-0100
S1 A/B	Switch, FS-24814 LS15H1-2-3	74440-1520
S2 A/B	Switch, FS-24938 ⑦ S15H(12)5-8-10F_1S_1/RV	74431-6080
J1 A/B	Connector, FS-17172 ③ (VG-625/U-N_1)	74500-2530
J2 A/B	Connector A4-394	74500-3170

CH1 · CH2 PREAMPLIFIER

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C36 A/B	Cap., cer, 0.01 μF, 50 V	74060-0560
C37 A/B	Cap., cer, 1000 pF, 50 V	74060-0700
C39 A/B	Same as C36	
C40 A/B	Cap., cer, 1000 pF, 50 V	74060-1750
C44 A/B	Cap., cer, 1 pF	74050-4770
C46 A/B	Same as C40	
C47 A/B	Same as C40	
C48 A/B	Same as C40	
C49 A/B	Cap., cer, var, 15 pF	74110-0800
C50 A/B	Cap., cer, var, 20 pF	74110-0630
C51 A/B	Cap., cer, 330 pF, 50 V	74060-2620
C52 A/B	Same as C51	
C61 A/B	Cap., cer, 5 pF	74050-2620
C62 A/B	Same as C61	
C65 A/B	Same as C51	
C66 A/B	Same as C51	
C67 A/B	Cap., elect, 10 μF, 25 V	74120-0830
C68 A/B	Same as C67	
C79 A/B	Cap., cer, var, 15 pF	74110-0800
C82 A/B	Cap., cer, var, 7 pF	74110-0600
C84 A/B	Same as C40	
C85 A/B	Same as C51	
C86 A/B	Same as C51	
C88 A/B	Same as C51	
C90 A/B	Same as C51	
C97 A/B	Same as C82	
C99 A	Cap., cer, 56 pF, 50 V	74050-2920
C99 B	Cap., cer, 51 pF, 50 V	74050-5520
C102 A/B	Same as C51	
C103 A/B	Same as C51	
C120 A/B	Same as C82	
C121 A/B	Cap., cer, 20 pF, 500 V	74050-5280
C122 A/B	Same as C51	
C123 A/B	Same as C51	
L67 A/B	Ferrite FS-24976 ②	74400-4740
L68 A/B	Same as L67	
L122 A/B	Ferrite L-RH03 x 03 x 01	74560-1240
L123 A/B	Same as L122	
R37 A/B	Res., 470 k, 1/2 W, 2 %	74241-1050
R38 A/B	Res., var, 20 k (TR10KB20kΩ)	74349-0690
R39 A/B	Res., 43 k, 1/4 W, 5 %	74230-1400
R40 A/B	Res., 300, 1/4 W, 5 %	74230-1160
R41 A/B	Res., 100, 1/4 W, 5 %	74230-0130
R42 A/B	Res., 5.6 k, 1/4 W, 5 %	74230-0520
R43 A/B	Same as R42	
R44A	Res., 33, 1/4 W, 5 %	74230-0280
R44B	Res., 10, 1/4 W, 5 %	74230-0070
R45A	Same as R44A	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R45B	Same as R44B	
R46 A/B	Res., 750, 1/4 W, 5 %	74230-0540
R47 A/B	Res., 1.5 k, 1/4 W, 5 %	74230-0110
R48 A/B	Same as R47	
R49 A/B	Same as R41	
R50 A/B	Res., var, 200 (TF06PV200Ω)	74349-0770
R51 A/B	Res., 240, 1/4 W, 5 %	74230-1250
R52 A/B	Same as R51	
R53 A/B	Res., 470, 1/4 W, 5 %	74230-0160
R54 A/B	Same as R53	
R55 A/B	Same as R53	
R56 A/B	Res., 510, 1/4 W, 5 %	74230-0450
R57 A/B	Res., var, 1 k (TR10KB1kΩ)	74349-0640
R58 A/B	Same as R56	
R59 A/B	Res., 100 k, 1/4 W, 5 %	74230-0260
R60 A/B	Res., var, 1 k	74322-2230
	(V16M5-2 S 10SU1k LN)	
R61 A/B	Res., 24, 1/4 W, 5 %	74230-1600
R62 A/B	Same as R61	
R63 A/B	Res., 2.7 k, 1/4 W, 5 %	74230-0420
R64 A/B	Same as R63	
R65 A/B	Res., 180, 1/4 W, 5 %	74230-0860
R66 A/B	Same as R65	
R67 A	Res., 120, 1/4 W, 5 %	74230-1130
R67 B	Res., 120, 1/4 W, 5 %	74230-1130
R68 A	Same as R67 A	
R68 B	Same as R67 B	
R69 A/B	Res., 150, 1/4 W, 5 %	74230-0510
R70 A/B	Res., 15, 1/4 W, 5 %	74230-1170
R71 A/B	Same as R70	
R74 A/B	Res., 360, 1/4 W, 5 %	74230-1110
R75 A/B	Same as R74	
R76 A/B	Res., 300, 1/4 W, 5 %	74230-1160
R77 A/B	Same as R76	
R78 A/B	Res., var, 100 (RV13YN10SB100Ω)	74321-0010
R79 A/B	Res., var, 100 (TF06PV100Ω)	74349-0830
R80 A/B	Same as R41	
R81 A/B	Same as R79	
R82 A/B	Res., 200, 1/4 W, 5 %	74230-1340
R85 A/B	Res., 130, 1/4 W, 5 %	74230-1150
R86 A/B	Same as R85	
R87A	Same as R67A	
R87B	Same as R67B	
R88 A/B	Same as R82	
R89A	Same as R67A	
R89B	Same as R67B	
R90 A/B	Same as R82	
R91 A/B	Res., 3.6 k, 1/4 W, 5 %	74230-1080
R92 A/B	Res., 1.8 k, 1/4 W, 5 %	74230-0810
R93A	Res., 56, 1/4 W, 5 %	74230-0940
R93B	Same as R44A	
R94A	Same as R93A	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R94B	Same as R44A	
R95A	Res., 750, 1/4 W, 5 %	74230-0540
R95B	Res., 620, 1/4 W, 5 %	74230-1040
R96A	Same as R95A	
R96B	Same as R95B	
R97A	Res., 91, 1/4 W, 5 %	74230-1230
R97B	Same as R85	
R98A	Same as R79A	
R99 A/B	Res., 910, 1/4 W, 5 %	74230-1260
R100B	Same as R50	
R101B	Res., 15, 1/4 W, 5 %	74230-1170
R102 A/B	Res., 160, 1/4 W, 5 %	74230-1410
R103 A/B	Same as R102	
R104A	Same as R67A	
R104B	Same as R67B	
R105A	Same as R67A	
R105B	Same as R67B	
R106B	Same as R67B	
R107B	Same as R67B	
R108A	Res., 51, 1/4 W, 5 %	74230-0600
R108B	Res., 27, 1/4 W, 5 %	74230-1380
R109B	Same as R108B	
R110 A/B	Res., 2.2 k, 1/4 W, 5 %	74230-0270
R111 A/B	Same as R110	
R112A	Res., 75, 1/4 W, 5 %	74230-0880
R112B	Res., 82, 1/4 W, 5 %	74230-1070
R113A	Same as R112A	
R113B	Same as R112B	
R114 A/B	Res., 12 k, 1/4 W, 5 %	74230-0440
R115 A/B	Same as R114	
R116 A/B	Res., var, 10 k	74323-0330
	(RV19YG20RB10kΩ x 2)	
R117 A/B	Same as R47	
R118 A/B	Same as R47	
R119 A/B	Res., var, 500 (λ13T500Ω)	74331-0770
R120 A/B	Same as R67A	
R121 A/B	Same as R63	
R122 A/B	Same as R40	
R123 A/B	Same as R40	
D36 A/B	Diode 1S-1544	74040-3630
D46 A/B	Diode RD-6A	74040-0790
D53 A/B	Diode 1S-1992	74040-3930
D54 A/B	Same as D53	
D76 A/B	Diode 1S-1458	74040-2920
D77 A/B	Same as D76	
D102B	Same as D76	
D103B	Same as D76	
D104B	Same as D76	
D105B	Same as D76	
D106B	Same as D76	
D107B	Same as D76	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D108B	Same as D76	
D109B	Same as D76	
TR42 A/B	Transistor T1S 27	74030-2810
TR47 A/B	Transistor 2N3571	74030-4770
TR48 A/B	Same as TR47	
TR65 A/B	Same as TR47	
TR66 A/B	Same as TR47	
TR74 A/B	Transistor MM4049	74030-4210
TR75 A/B	Same as TR74	
TR87 A/B	Transistor 2N4260	74030-3600
TR89 A/B	Same as TR87	
TR95 A/B	Same as TR74	
TR96 A/B	Same as TR74	
TR117 A/B	Same as TR47	
TR118 A/B	Same as TR47	
S108B	Switch FS-24488 SLP1-2-2	74440-1380
NE59 A/B	Neon lamp NE-2	74020-1110

SWITCHING CIRCUIT

C127	Cap., cer, 1000 pF, 50 V	74060-1750
C131	Cap., cer, 330 pF, 50 V	74060-2620
C132	Same as C131	
C133	Cap., cer, 1000 pF, 50 V	74060-0700
C134	Same as C133	
C136	Cap., cer, 12 pF, 50 V	74050-4450
C137	Same as C136	
C139	Same as C133	
C265	Same as C127	
C281	Cap., poly, 0.0068 μF, 500 V	74130-4150
C282	Cap., poly, 0.22 μF, 50 V	74130-2330
C283	Same as C127	
C285	Cap., cer, 100 pF, 50 V	74050-1710
C291	Cap., elect 10 μF, 25 V	74120-0830
C292	Same as C127	
C293	Same as C291	
C294	Same as C127	
C295	Same as C133	
L265	Inductor FS-24976-2	74400-4740
L291	Same as L265	
L292	Same as L265	
L293	Same as L265	
L294	Same as L265	
R125	Res., 2.2 k, 1/4 W, 5 %	74230-0210
R126	Same as R125	
R127	Res., 1 k, 1/4 W, 5 %	74230-0030
R128	Same as R127	
R129	Res., 300, 1/4 W, 5 %	74230-1160
R130	Same as R129	
R131	Res., 270, 1/4 W, 5 %	74230-0910
R132	Same as R131	
R133	Res., 470, 1 W, 2 %	74242-0220
R134	Same as R133	
R135	Res., 330, 1/2 W, 2 %	74242-0320
R136	Res., 47, 1/4 W, 5 %	74230-0100
R137	Same as R136	
R138	Res., 550, 5 W, 1 %	74291-1350
R139	Res., 1 k, 1/2 W, 2 %	74241-0440
R265	Same as R128	
R266	Same as R128	
R267	Res., 120, 1/4 W, 5 %	74230-1130
R268	Same as R267	
R269	Res., 200, 1/4 W, 5 %	74230-1340
R270	Same as R269	
R271	Res., 18, 1/4 W, 5 %	74230-1060
R272	Same as R271	
R273	Same as R127	
R274	Same as R127	
R275	Res., 1.8 k, 1/4 W, 5 %	74230-0350
R276	Same as R275	
R277	Res., 3.3 k, 1/4 W, 5 %	74230-0350
R279	Res., 130, 1/4 W, 5 %	74230-1150
R280	Same as R279	
R281	Res., 27, 1/4 W, 5 %	74230-1380
R282	Res., 620, 1/4 W, 5 %	74230-1040
R283	Res., 16 k, 1/4 W, 5 %	74230-1510
R285	Res., 20 k, 1/4 W, 5 %	74230-0310
R286	Res., 2.7 k, 1/4 W, 5 %	74230-0420
R287	Res., 240, 1/4 W, 5 %	74230-1250
R289	Same as R275	
R290	Res., 3.9 k, 1/4 W, 5 %	74230-0090
D125	Diode 1S-1458	74040-2920
D126	Same as D125	
D127	Same as D125	
D128	Same as D125	
D129	Same as D125	
D130	Same as D125	
D131	Same as D125	
D132	Same as D125	
D273	Diode 1S-953	74040-1720
D274	Same as D273	
D275	Same as D273	
D276	Same as D273	
D277	Same as D273	
D279	Same as D125	
D280	Same as D125	
D282	Same as D273	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
TR131	Transistor 2N3571	74030-4750
TR132	Same as TR131	
TR273	Transistor 2N4258	74030-3150
TR274	Same as TR273	
TR282	Transistor 2N4121	74030-2990
TR286	Transistor 2N4275	74030-3160
TR289	Same as TR286	
S271 A/B	Switch FS-24760-2	74431-6030
P4	Connector 26-159-24	74500-0430
T280	Transformer P-F19002 3	74400-4070

TRIGGER AMPLIFIER

C141	Cap., cer, 1000 pF, 50 V	74060-1750
C142	Cap., cer, 0.01 μF	74060-0560
C143	Same as C141	
C144	Cap., cer, 1000 pF, 50 V	74060-0560
C149 A/B	Cap., cer, var, 7 pF	74110-0600
C152 A/B	Cap., cer, 330 pF, 50 V	74060-2620
C153 A/B	Same as C152	
C160 A/B	Same as C149	
C164 A/B	Same as C152	
C165 A/B	Same as C152	
C172 A/B	Same as C149	
C175 A/B	Same as C152	
C176 A/B	Same as C152	
C177 A/B	Same as C141	
C189	Cap., cer, var, 20 pF	74110-0630
C190	Cap., cer, var, 15 pF	74110-1030
C193	Same as C152	
C194	Same as C152	
L141	Inductor FL5H100K	74470-0950
L142	Same as L141	
R140 A/B	Res., 91, 1/4 W, 5 %	74230-1230
R141 A/B	Same as R140	
R142 A/B	Res., 15, 1/4 W, 5 %	74230-1170
R143 A/B	Same as R142	
R144 A/B	Res., 4.7 k, 1/4 W, ±5 %	74230-0290
R145 A/B	Same as R144	
R146 A/B	Res., 1.5 k, 1/4 W, 5 %	74230-0110
R147A	Res., 36, 1/4 W, 5 %	74230-1490
R147B	Res., 33, 1/4 W, 5 %	74230-0280
R148A	Same as R147A	
R148B	Same as R147B	
R149 A/B	Res., 110, 1/4 W, 5 %	74230-1520
R150 A/B	Res., 1.8 k, 1/4 W, 5 %	74230-0810
R151 A/B	Same as R150	
R152 A/B	Res., 300, 1/4 W, 5 %	74230-1160
R153 A/B	Same as R152	
R154 A/B	Res., 120, 1/4 W, 5 %	74230-1130
R155 A/B	Same as R154	
R156 A/B	Res., 510, 1/4 W, 5 %	74230-0450
R158 A/B	Res., 47, 1/4 W, 5 %	74230-0100
R159 A/B	Same as R158	
R160 A/B	Same as R149	
R161 A/B	Same as R156	
R162 A/B	Same as R156	
R163 A/B	Res., var, 100 (TF06PV100 Ω)	74349-0830
R164 A/B	Res., 220, 1/4 W, 5 %	74230-0480
R165 A/B	Same as R164	
R166 A/B	Same as R154	
R167 A/B	Same as R154	
R168A	Res., 180, 1/4 W, 5 %	74230-0860
R168B	Res., var, 500 (TF06PV500 Ω)	74349-0760
R169A	Res., 62, 1/4 W, 5 %	74230-1240
R169B	Res., 56, 1/4 W, 5 %	74230-0940
R170A	Same as R169A	
R170B	Same as R169B	
R172A	Res., 100, 1/4 W, 5 %	74230-0130
R172B	Res., var, 200 (TF06PV200 Ω)	74349-0770
R173 A/B	Res., 360,1/4 W, 5 %	74230-1110
R174 A/B	Same as R173	
R175 A/B	Same as R173	
R176 A/B	Same as R173	
R177 A/B	Same as R172A	
R178 A/B	Res., 15 k, 1/4 W, 5 %	74230-0140
R179	Res., 390, 1/4 W, 5 %	74230-0550
R180	Same as R179	
R181	Res., 470, 1/2 W, 2 %	74241-0360
R182	Same as R181	
R183	Same as R152	
R184	Res., 240, 1 W	74242-0170
R185	Res., var, 100 (λ 13T100 Ω)	74331-0500
R186	Res., 75, 1/4 W, 5 %	74230-0600
R187	Same as R186	
R188	Same as R172B	
R189	Same as R142	
R190	Same as R168B	
R191	Same as R156	
R192	Same as R156	
R193	Res., 680, 1/4 W, 5 %	74230-0150
R194	Same as R193	
R195	Res., 2 k, 1/4 W, 5 %	74230-0410
R196	Same as R195	
R197	Res., 51, 1/4 W, 5 %	74230-0600
R198	Same as R197	
R199	Same as R172B	
R200	Same as R197	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D175 A/B	Diode 1S-1458	74040-2920
D176 A/B	Same as D175	
D177 A/B	Same as D175	
D178 A/B	Same as D175	
TR144 A/B	Transistor, μPA 15	74030-1520
TR150 A/B	Transistor, 2N 5179	74030-4310
TR151 A/B	Same as TR150	
TR161 A/B	Same as TR150	
TR162 A/B	Same as TR150	
TR173 A/B	Transistor, 2N 4260	74030-3600
TR174 A/B	Same as TR173	
TR179	Same as TR173	
TR180	Same as TR173	
TR189	Transistor, 2N4258	74030-3150
TR190	Same as TR189	
J196	Connector UG-625/U-Ni	74500-2530

VERTICAL MAIN AMPLIFIER

C203	Cap., cer, var, 7 pF	74110-0600
C205	Cap., cer, var, 20 pF	74110-0630
C207	Cap., cer, 120 pF, 50 V	74050-4970
C210	Cap., cer, 330 pF, 50 V	74060-2620
C211	Same as C210	
C216	Same as C210	
C217	Same as C210	
C218	Cap., cer, 0.001 μF, 50 V	74060-0700
C220	Cap., cer, 20 pF, 50 V	74050-5280
C221	Same as C220	
C224	Same as C203	
C230	Cap., cer, 0.001 μF,50 V	74060-1750
C231	Same as C230	
C232	Same as C218	
C233	Same as C218	
C234	Same as C218	
C239	Cap., cer, 2 pF	74050-1690
C244	Same as C203	
C258	Cap., cer, 0.01 μF, 500 V	74060-0730
C259	Same as C218	
L201	Inductor P-F24039 ②	74400-2840
L202	Inductor P-F23934	74400-2780
L203	Inductor FS-24038	74400-2860
L204	Same as L202	
L205	Same as L203	
L207	Ferrite L-RH03 x 03 x 01	74560-0090
L208	Same as L207	
R201	Res., 120, 1/4 W, 5 %	74230-1130
R202	Res., var, 100 (TF06PV100 Ω)	74349-0830
R203	Res., 10, 1/4 W, 5 %	74230-0070
R204	Same as R203	
R205	Res., var, 1 k (TF06PV1K Ω)	74349-1280
R206	Res., 82, 1/4 W, 5 %	74230-1070
R207	Res., 1.5 k, 1/4 W, 5 %	74230-0110
R208	Same as R207	
R209	Same as R207	
R210	Res., 330, 1/4 W, 5 %	74230-0470
R211	Same as R210	
R212	Res., 20, 1/4 W, 5 %	74230-1140
R213	Same as R212	
R214	Res., 12 k, 1/2 W, 2 %	74241-0670
R215	Res., 2.4 k, 1/4 W, 5 %	74230-0220
R216	Res., 240, 1/4 W, 5 %	74230-1250
R217	Same as R216	
R218	Res., 8.2 k, 1/4 W, 5 %	74230-0430
R219	Same as R218	
R220	Res., 130, 1/4 W, 5 %	74230-1150
R221	Same as R220	
R222	Res., 30, 1/4 W, 5 %	74230-0080
R223	Same as R222	
R224	Res., var, 50 (TF06PV50 Ω)	74349-0160
R225	Res., 100, 1/4 W, 5 %	74230-0130
R226	Same as R202	
R227	Res., 750, 1/2 W, 5 %	74230-0380
R228	Same as R227	
R229	Res., 390, 1/4 W, 5 %	74230-0550
R230	Res., 62, 1/4 W, 5 %	74230-1240
R231	Same as R230	
R232	Res., 33, 1/4 W, 5 %	74230-0280
R233	Res., 150, 1/4 W, 5 %	74230-0510
R234	Same as R233	
R235	Res., 47, 1/4 W,5 %	74230-0100
R236	Same as R235	
R237	Res., 1 k, 1 W, 2 %	74242-0300
R238	Same as R237	
R239	Same as R203	
R240	Same as R203	
R241	Res., 330, 2 W, 2 %	74243-0240
R242	Same as R241	
R243	Same as R206	
R244	Res., var, 500 (TF06PV500 Ω)	74349-0760
R245	Res., 560, 1/2 W, 2 %	74241-0380
R248	Res., 370, 5 W, 1 %	74291-1360
R251	Res., 100, 2 W, 2 %	74243-0170
R252	Res., 91, 2 W, 2 %	74243-1030
R253	Same as R251	
R254	Same as R252	
R256	Same as R224	
R257	Res., 43, 1 W, 2 %	74242-1130
R258	Same as R257	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R259	Same as R257	
D220	Diode 1S1458	74040-2920
D239	Diode HW6.8B	74040-4230
D240	Same as D239	
TR210	Transistor BFY90	74030-4960
TR211	Same as TR210	
TR212	Same as TR210	
TR213	Same as TR210	
TR222	Transistor BFW30	74030-4620
TR223	Same as TR222	
TR235	Same as TR222	
TR236	Same as TR222	
TR239	Transistor 2N5109	74030-4610
TR240	Same as TR239	
S201a	Switch MSP-206R	74430-0080
S202	Switch MST-106D	74430-0350
J201	Connector 26-190-24	74500-0440
W201	Cable FS-21568 ③ CD-5	52850-5005

A TRIGGER GENERATOR

C301	Cap., cer, 15 pF, 50 V	74050-1730
C302	Cap., cer, 7 pF, 500V	74050-0330
C303	Cap., cer, 1 pF, 500 V	74050-0260
C304	Cap., cer, 0.01 μF, 500 V	74060-0730
C305	CAp., cer, 100 pF, 500 V	74050-0690
C306	Cap., cer, 0.001 μF, 500 V	74060-0700
C307	Cap., cer, 0.01 μF, 25 V	74060-0560
C308	Cap., cer, 5 P, 50 V	74050-2620
C309	Same as C301	
C310	Cap., cer, 22 pF, 50 V	74050-3050
C311	Same as C307	
C312	Same as C307	
C313	Same as C307	
C314	Same as C307	
C315	Same as C306	
C316	Cap., cer, 0.1 μF $^{+80\ \%}_{-20\ \%}$, 25 V	74060-1130
C317	Cap., cer, 68 pF‘ 50 V	74050-3390
C318	Cap., cer, 27 p, 50 V	74050-2040
C320	Cap., Tantalum 3.3 μF 25 V	74120-2720
C321	Same as C316	
C323	Cap., cer, 6 pF, 500 V	74050-2660
C325	Same as C305	
C326	Same as C316	
C330	Cap., elect, 33 μF, 25 V	74120-3080
C331	Cap., elect, 47 μF, 25 V	74120-2250

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
L300	Inductor FS-24034	74473-0400
L301	Inductor FS-24035	74473-0390
R300	Res., 10, 1/4 W, 5 %	74253-0440
R301	Res., 300, 1/4 W, 5 %	74253-0760
R302	Res., 910 k, 1/4 W, 5 %	74253-1380
R303	Res., 110 k, 1/4 W, 5 %	74253-1300
R304	Res., 100 k, 1/4 W, 5 %	74253-1290
R305	Same as R304	
R306	Res., 1 M, 1/2 W, 2 %	74241-1130
R307	Res., 1 M, 1/4 W, 5 %	74253-0210
R308	Res., 47, 1/4 W, 5 %	74253-0070
R309	Res., var, 10 k x 2 (RV 19 YD(3) 31B10 kΩx 2(9)	74323-0100
R310	Res., var, 10 k (TR10 kB 10 kΩ)	74349-0660
R311	Res., 20 k, 1/4 W, 5 %	74253-0270
R312	Res., 10 k, 1/4 W, 5 %	74253-1160
R313	Res., 1 k, 1/4 W, 5 %	74253-0500
R314	Same as R308	
R315	Same as R313	
R316	Res., 5.1 k, 1/4 W, 5 %	74253-1100
R317	Same as R316	
R318	Res., 820, 1/4 W, 5 %	74253-1000
R319	Res., 3.9 k, 1/4 W, 5 %	74253-1090
R320	Same as R319	
R321	Res., 620, 1/4 W, 5 %	74253-0990
R322	Res., 430, 1/4 W, 5 %	74253-0970
R323	Same as R322	
R324	Res., 3 k, 1/4 W, 5 %	74253-1060
R325	Same as R324	
R326	Res., 150, 1/4 W, 5 %	74253-0580
R327	Same as R326	
R328	Res., 430, 1/4 W, 5 %	74253-0970
R329	Same as R328	
R330	Res., 1.8 k, 1/4 W, 5 %	74253-1020
R331	Same as R330	
R332	Same as R326	
R333	Same as R324	
R334	Same as R324	
R335	Res., 100, 1/4 W, 5 %	74253-0080
R336	Same as R304	
R337	Same as R304	
R338	Res., 110, 1/4 W, 5 %	74253-0860
R339	Res., 68, 1/4 W, 5 %	74253-0430
R340	Res., 43, 1/4 W‘ 5 %	74253-0740
R341	Same as R308	
R342	Same as R308	
R343	Same as R335	
R345	Same as R316	
R346	Same as R335	
R347	Res., 4.7 k, 1/4 W, 5 %	74253-0130
R350	Res., 33 k, 1/4 W, 5 %	74253-1230

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R351	Same as R304	
R352	Res., 270, 1/4 W, 5 %	74253-0930
R353	Res., 12 k, 1/4 W, 5 %	74253-1170
R354	Same as R330	
R355	Same as R304	
R356	Same as R308	
R357	Same as R324	
R358	Res., 6.8 k, 1/4 W, 5 %	74253-1130
R359	Same as R358	
R365	Same as R300	
R366	Same as R300	
R368	Same as R335	
R369	Res., 33, 1/4 W, 5 %	74253-0720
R370	Same as R316	
R371	Same as R338	
D300	Diode RD 5A	74040-0770
D301	Diode 1S 1458	74040-2920
D302	Same as D301	
D303	Same as D301	
D304	Same as D301	
D305	Diode RD 11A	74040-0870
D306	Diode 1S 1760	74040-2900
D307	Diode SD 18	74040-1060
D308	Same as D301	
D310	Same as D301	
D312	Same as D301	
D313	Same as D301	
D314	Same as D301	
D315	Same as D301	
D316	Diode 1S 1544	74040-3670
D317	Same as D316	
TR300	Transistor 2N 4223	74030-0700
TR301	Same as TR300	
TR302	Transistor 2N 4275	74030-3160
TR303	Same as TR302	
TR304	Transistor 2SC 689 Ⓗ	74030-3660
TR305	Same as TR304	
TR306	Transistor 2N 4258	74030-3150
TR307	Same as TR306	
TR308	Same as TR306	
TR309	Same as TR306	
TR310	Same as TR304	
TR320	Same as TR302	
TR321	Same as TR302	
TR322	Transistor 2N 4121	74030-2990
TR324	Same as TR302	
S300	Switch LS-P 1-3-4	74440-1360
S301	Switch LS-P 1-1-4	74440-1370
S302	Switch LS-P 1-2-2	74440-1380
S303	Switch LS-P 1-3-4	74440-1202
J300	Connector UG-625/U Ni	74500-2530
TB300	Ground terminal	74510-0140
T300	Transformer FS-24037 ③	74473-0513
T302	Same as T300	
RL300	Relay SM-12	74450-0640
R491	Res., var 10 k x 2 (RV 19 YD(3) 31B 10 kΩ x 2(9)	74323-0100

A SWEEP GENERATOR

C380	Cap., cer, 330 pF, 50 V	74050-3040
C390	Cap., elect, 10 μF, 25 V	74120-0830
C391	Same as C390	
C392	Cap., cer, 0.001 μF, 500 V	74060-0700
C393	Cap., elect, 10 μF, 16 V	74120-3110
C395	Same as C392	
C398	Cap., cer, 0.0022 μF, 50 V	74060-1580
C400	Same as C392	
C401	Same as C392	
C402	Cap., cer, 47 pF, 50 V	74050-2730
C403	Cap., cer, var, 25 pF	74110-0110
C404	Same as C402	
C405	Same as C402	
C406	Cap., cer, 39 pF, 50 V	74050-3380
C407	Cap., cer, 10 pF, 50 V	74050-1780
C408	Same as C392	
C409	Same as C392	
C411	Cap., elect, 100 μF, 16 V	74120-3020
C412	Same as C380	
C414	Cap., cer, 22 pF, 50 V	74050-3050
C415	Cap., cer, 100 pF, 50 V	74050-1710
C416	Same as C392	
C427	Cap., elect, 47 μF, 25 V	74120-2250
C428	Same as C427	
C429	Same as C392	
C461	Cap., cer, 0.01 μF, 500 V	74060-0730
R379	Res., 4.7 k, 1/4 W, 5 %	74253-0130
R380	Res., 1 k, 1/4 W, 5 %	74253-0500
R381	Res., 2.2 k, 1/4 W, 5 %	74253-1030
R382	Same as R381	
R383	Res., 200, 1/4 W, 5 %	74253-0370
R386	Res., 2 k, 1/2 W, 2 %	74241-0490
R387	Res., 100, 1/4 W, 5 %	74253-0080
R388	Same as R379	
R389	Res., 1.5 k, 1/4 W, 5 %	74253-0540
R390	Res., 10, 1/4 W, 5 %	74253-0440
R391	Same as R390	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R392	Res., 15 k, 1/4 W, 5 %	74253-1180
R393	Res., 2 k, 1/4 W, 5 %	74253-0510
R394	Same as R379	
R395	Res., 750, 1/2 W, 2 %	74241-0410
R396	Res., 390, 1/2 W, 2 %	74241-0340
R397	Res., 3 k, 1/4 W, 5 %	74253-1060
R398	Same as R396	
R399	Res., 82, 1/2 W, 2 %	74241-0180
R400	Res., 12 k, 1/4 W, 5 %	74253-1170
R401	Res., 150, 1/4 W, 5 %	74253-0580
R402	Same as R379	
R403	Res., 82, 1/4 W, 5 %	74253-0810
R404	Same as R392	
R405	Same as R383	
R406	Res., 470, 1/4 W, 5 %	74253-0490
R407	Res., 820, 1/4 W, 5 %	74253-1000
R408	Same as R392	
R409	Same as R393	
R410	Res., 510, 1/4 W, 5 %	74253-0980
R411	Res., 1.8 k, 1/4 W, 5 %	74253-1020
R412	Same as R397	
R413	Same as R380	
R414	Res., 3.9 k, 1/4 W, 5 %	74253-1090
R415	Res., 100, 1/4 W, 5 %	74253-0080
R416	Res., 30 k, 1/4 W, 5 %	74253-1220
R417	Same as R415	
R418	Res., 47, 1/4 W, 5 %	74253-0070
R419	Same as R380	
R420	Same as R392	
R421	Res., 7.5 k, 1/4 W, 5 %	74253-1140
R422	Same as R380	
R423	Same as R392	
R424	Res., 56, 1/4 W, 5 %	74253-0770
R425	Same as R415	
R426	Same as R418	
R427	Res., 12 k, 2 W, ± 2 %	74243-0590
R428	Res., 75 k, 2 W, 2 %	
R430	Same as R415	
R431	Same as R415	
R432	Same as R415	
R433	Res., 6.8 k, 2 W, 2 %	74243-0530
R434	Same as R418	
R435	Res., 510, 1/4 W, 5 %	74253-0980
R436	Same as R393	
R437	Same as R380	
R438	Res., 330, 1/4 W, 5 %	74253-0950
R439	Same as R401	
R441	Same as R415	
R442	Res., 1.5 M, 1/4 W, 5 %	74281-0270
R443	Same as R418	
R444	Same as R418	
R445	Res., 9.1 k, 1 W, 2 %	74242-0510
R446	Same as R438	
R447	Same as R393	74241-0010
R448	Res., var, 1 k (TR 10 KB 1 kΩ)	74349-0640
R449	Same as R410	
R450	Same as R406	
R451	Same as R414	
R452	Same as R401	
R453	Res., 3.6 k, 1/4 W, 5 %	74253-1080
R454	Res., 910, 1/2 W, 2 %	74241-0430
R455	Res., 430, 1/4 W, 5 %	74253-0970
R456	Same as R397	
R458	Same as R389	
R459	Res., 8.2 k, 1/4 W, 5 %	74253-0550
R460	Res., 20 k, 1/4 W, 5 %	74253-0270
R461	Res., 100 k, 1/4 W, 5 %	74253-1290
R462	Res., 10 k, 1/4 W, 5 %	74253-1160
R463	Res., var, 5 k (TR 10 KB 5 kΩ)	74349-0620
R464	Res., 220 k, 1/4 W, 5 %	74253-1350
R465	Res., 22 k, 1/4 W, 5 %	74253-1200
R466	Same as R461	
R467	Res., 5.1 k, 1/4 W, 5 %	74253-1100
R470	Same as R418	74253-0070
R477	Res., 10, 1/2 W, 2 %	74241-0010
R478	Same as R477	
R479	Same as R477	
D380	Diode 1S 1458	74040-2920
D381	Same as D380	
D392	Diode RD 6A	74040-0790
D393	Diode 1S 1760	74040-2900
D394	Diode 1S 953	74040-1720
D400	Same as D393	
D401	Same as D394	
D402	Same as D394	
D403	Same as D380	
D404	Diode RD 9A	74040-0840
D405	Same as D394	
D406	Same as D392	
D407	Same as D394	
D408	Same as D394	
D409	Same as D394	
D410	Same as D404	
D411	Same as D394	
D412	Same as D394	
D413	Same as D394	
D414	Same as D394	
D415	Same as D394	
D417	Same as D394	
D418	Same as D394	
D419	Same as D394	
D420	Same as D394	
D421	Same as D393	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D422	Diode SD 104	74040-1160
D423	Same as D394	
TR380	Transistor 2N 4275	74030-3160
TR381	Same as TR380	
TR382	Transistor 2N 4121	74030-2990
TR394	Same as TR380	
TR395	Same as TR382	
TR400	Transistor 2N 4258	74030-3150
TR401	Same as TR380	
TR402	Same as TR380	
TR403	Same as TR380	
TR404	Same as TR382	
TR405	Transistor 2SK12-GR	74030-2940
TR406	Same as TR380	
TR407	Same as TR382	
TR408	Same as TR382	
TR409	Same as TR382	
TR410	Transistor 2N 4360	74030-3710
TR411	Same as TR382	
TR412	Same as TR382	
TR413	Same as TR380	
TR414	Same as TR380	
TR415	Transistor 2SC 154 H.B	74030-1500
S395, (NE400)	Switch and Neon lamp PSN-5	74440-0560
S400 A/B	Switch S22P-5-15-4/S22P(6) 1-4-2	74431-5370
J400	Connector UG-625/U-Ni	74500-2530
NE400	Same as S395	

B TRIGGER GENERATOR

C500	Cap., cer, 15 pF, 50 V	74050-1730
C501	Cap., cer, 5 pF, 500 V	74050-0300
C502	Cap., cer, var, 5 pF	74110-0430
C503	Cap., cer, 0.01 μF, 500 V	74060-0730
C504	Cap., cer, 100 pF, 500 V	74050-0690
C505	Cap., cer, 0.001 μF, 500 V	74060-0700
C507	Same as C505	
C508	Same as C505	
C509	Same as C505	
C512	Cap., cer, 0.01 μF, 50 V	74060-0560
C513	Cap., cer, 0.01 μF, 25 V	74060-0560
C514	Same as C513	
C515	Cap., cer, 0.1 μF $^{+80}_{-20}$ %, 25 V	74060-1130
C516	Cap., cer, 47 pF, 50 V	74050-2730
C517	Same as C516	
C519	Cap., cer, 68 pF, 50 V	
C523	Cap., cer, 15 pF, 500 V	74050-0460
C561	Cap., elect, 33 μF, 25 V	74120-3080
C562	Same as C561	
L500	Inductor FS-24034	74400-2830
R500	Res., 10, 1/4 W, 5 %	74253-0440
R501	Res., 910 k, 1/2 W, 2 %	74241-1120
R502	Res., 120 k, 1/2 W, 2 %	74241-0910
R503	Res., 100 k, 1/4 W, 5 %	74253-1290
R504	Same as R503	74253-1290
R505	Res., 1 M, 1/2 W, 2 %	74241-1130
R506	Res., 1 M, 1/4 W, 5 %	74253-0210
R507	Res., 47, 1/4 W, 5 %	74253-0070
R509	Res., 1.5 k, 1/4 W, 5 %	74253-0540
R510	Res., 20 k, 1/4 W, 5 %	74253-0270
R511	Res., 3.9 k, 1/4 W, 5 %	74253-1090
R512	Res., 100, 1/4 W, 5 %	74253-0080
R513	Same as R510	
R514	Same as R511	
R515	Same as R512	
R516	Same as R510	
R517	Same as R511	
R518	Same as R512	
R521	Res., 750, 1/4 W, 5 %	74253-1460
R522	Res., 4.7 k, 1/4 W, 5 %	74253-0130
R523	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R524	Same as R522	
R525	Res., 150, 1/4 W, ±5 %	74253-0580
R526	Res., var, 10 k (TR 10 KB 10 kΩ)	74349-0660
R527	Res., 5.6 k, 1/4 W, 5 %	74253-0450
R528	Res., 1 k, 1/4 W, 5 %	74253-0500
R529	Res., 27 k, 1/4 W, 5 %	74253-1470
R530	Res., var, 10 k (RV 16 YN 18 RB 10 kΩ)	74322-1070
R533	Same as R503	
R534	Same as R503	
R535	Res., 620, 1/2 W, 2 %	74241-0390
R536	Res., 75, 1/4 W, 5 %	74253-0800
R537	Same as R512	
R538	Res., 39 k, 1/2 W, 2 %	74241-0790
R539	Res., 39, 1/4 W, 5 %	74253-0730
R540	Res., 22, 1/4 W, 5 %	74253-0690
R541	Same as R512	
R542	Same as R522	
R543	Res., 82, 1/4 W, 5 %	74253-0810
R545	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R546	Res., var, 10 k (TR 10 KB 10 kΩ)	74349-0660
R548	Res., 10 k, 1/4 W, 5 %	74253-1160
R549	Same as R526	
R550	Res., 7.5 k, 1/4 W, 5 %	74253-1140
R551	Res., 200, 1/4 W, 5 %	74253-0370

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R552	Res., 8.2 k, 1/4 W, 5 %	74253-0550
R553	Same as R509	
R554	Res., 33, 1/4 W, 5 %	74253-0720
R555	Res., 4.3 k, 1/4 W, 5 %	74253-0600
R561	Same as R500	
R562	Same as R500	
D500	Diode RD 6A	74040-0790
D501	Diode 1S 1458	74040-0790
D502	Same as D501	
D503	Same as D501	
D505	Same as D501	
D506	Same as D501	
D507	Same as D501	
D508	Same as D501	
D509	Diode 1S 1760	74040-2900
D510	Diode SD 18	74040-1060
D511	Diode 1S 953	74040-1720
D512	Diode 1S 1544	74040-3670
D513	Same as D512	
TR500	Transistor 2N 4223	74030-2700
TR501	Transistor 2N 4275	74030-3160
TR502	Transistor 2SC 689 H	74030-3660
TR503	Same as TR502	
TR504	Same as TR501	
TR505	Transistor 2N 4258	74030-3150
TR507	Same as TR505	
TR508	Same as TR501	
S500	Switch FS-24486	74440-1360
S501	Switch FS-24487	74440-1370
S502	Switch FS-24488	74440-1380
S503	Same as S502	
J500	Connector UG-625/U-Ni	74500-2532
T500	Transformer FS-24037-3	74400-2823

B SWEEP GENERATOR

C600	Cap., cer, 0.001 μF, 500 V	74060-0700
C601	Same as C600	
C602	Cap., cer, 47 pF, 50 V	
C603	Same as C602	
C604	Cap., cer, 15 pF, 50 V	74050-1700
C605	Same as C602	
C606	Cap., cer, 39 pF, 50 V	74050-3380
C607	Cap., cer, var, 25 pF, 500 V	74110-0110
C608	Same as C600	
C609	Same as C600	
C610	Cap., cer, 0.1 μF $^{+\ 80}_{-\ 20}$ %, 25 V	74060-1130
C611	Cap., cer, 330 pF, 50 V	74050-2730
C612	Cap., cer, var, 8 pF, 500 V	74110-0070
C613	CAp., cer, 22 pF, 50 V	74050-3050
C614	Cap., cer, 100 pF, 50 V	74050-1710
C615	Same as C600	
C677	Cap., elect, 47 μF, 25 V	74120-2250
C678	Cap., elect, 33 μF, 25 V	74120-3080
R600	Res., 5.6 k, 1/4 W, 5 %	74253-0450
R601	Res., 6.8 k, 1/4 W, 5 %	74253-1130
R602	Res., 150, 1/4 W, 5 %	74258-0580
R603	Res., 4.7 k, 1/4 W, 5 %	74253-0130
R604	Res., 1 k, 1/2 W, 2 %	74241-0440
R605	Res., 3 k, 1/4 W, 5 %	74253-1060
R606	Res., 510, 1/4 W, 5 %	74253-0980
R607	Res., 1.8 k, 1/4 W, 5 %	74253-1020
R608	Same as R605	
R609	Res., 1 k, 1/4 W, 5 %	74253-0500
R610	Res., 3.9 k 1/4 W, 5 %	74253-1090
R611	Res., 100, 1/4 W, 5 %	74253-0080
R612	Res., 30 k, 1/4 W, 5 %	74253-1220
R613	Same as R611	
R614	Res., 7.5 k, 1/4 W, 5 %	74253-1140
R615	Same as R611	
R616	Res., 47, 1/4 W, 5 %	74253-0070
R617	Res., 15 k, 1/4 W, 5 %	74253-1180
R618	Same as R609	
R619	Same as R609	
R620	Same as R617	
R622	Res., 56, 1/4 W, 5 %	74253-0770
R623	Same as R616	
R624	Res., 7.5 k, 2 W, 2 %	74243-0540
R625	Res., 12 k, 2 W, 2 %	74243-0590
R626	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R628	Same as R611	74241-0590
R629	Same as R611	
R630	Res., 6.8 k, 2 W, 2 %	74243-0530
R631	Same as R616	
R632	Same as R606	
R633	Res., 2 k, 1/4 W, 5 %	74253-0510
R634	Same as R609	74253-0500
R635	Res., 330, 1/4 W, 5 %	74253-0950
R636	Same as R602	
R639	Res., 1.5 M, 1/4 W, 5 %	74281-0270
R640	Same as R611	
R641	Same as R616	
R642	Same as R616	
R643	Res., 9.1 k, 1 W, 2 %	74242-0510
R644	Same as R635	
R645	Same as R633	
R646	Res., var, 1 k (TR 10 KB 1 kΩ)	74349-0640
R647	Same as R606	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R648	Res., 300, 1/4 W, 5 %	74953-0940
R649	Same as R610	
R650	Same as R602	
R651	Res., 3.6 k, 1/4 W, 5 %	74253-1080
R652	Res., 910, 1/2 W‘ 2 %	74241-0430
R653	Res., 430, 1/4 W, 5 %	74253-0970
R654	Same as R605	
R656	Res., 1.5 k, 1/4 W, 5 %	74253-0540
R657	Res., 8.2 k, 1/4 W, 5 %	74253-0550
R658	Res., 10 k, 1/4 W, 5 %	74253-1160
R659	Res., var, 5 k (TR 10 KB 5 kΩ)	74349-0620
R660	Res., 5.1 k, 1/4 W, 5 %	74253-1100
R661	Same as R603	
R662	Same as R658	
R663	Same as R633	
R664	Res., 2.2 k, 1/4 W, 5 %	74253-1030
R665	Same as R605	
R670	Same as R616	
R674	Same as R601	
R677	Res., 10, 1/2 W, 2 %	74241-0010
R678	Same as R677	
R679	Same as R677	
D600	Diode 1S 1760	74040-2900
D601	Diode 1S 953	74040-1720
D602	Same as D601	
D603	Diode RD 9A	74040-0840
D604	Diode 1S 1458	74040-2920
D605	Same as D601	
D606	Same as D601	
D607	Same as D601	
D608	Same as D601	
D609	Diode RD 6A	74040-0790
D610	Same as D601	
D611	Same as D603	
D612	Same as D601	
D614	Same as D601	
D615	Same as D601	
D616	Same as D601	
D618	Same as D601	
D619	Same as D601	
D620	Same as D601	
D621	Same as D601	
D622	Same as D600	
D624	Same as D601	
D625	Same as D601	
TR600	Transistor 2N 4258	74030-3150
TR601	Transistor 2N 4275	74030-3160
TR602	Same as TR601	
TR603	Transistor 2N 4121	74030-2990
TR604	Transistor 2 SK 12-GR	74030-2970
TR605	Same as TR603	
TR606	Transistor 2N 4121	74030-2990
TR607	Same as TR603	
TR608	Same as TR603	
TR609	Transistor 2N 4360	74030-3710
TR610	Same as TR603	
TR611	Same as TR603	
TR612	Same as TR601	
TR613	Same as TR601	
TR614	Same as TR601	
J600	Connector UG-625/U-Ni	74500-2530

<A SWEEP BOARD>

C571	Cap., cer, 0.01 μF, 25 V	74060-0560
C572	Cap., elect, 100μF, 16 V	74120-3020
C574	Same as C571	
C576	Cap., cer, 0.0033 μF, 50 V	74060-2460
C580	Same as C571	
C581	Same as C571	
R571	Res., 33, 1/4 W, 5 %	74253-0720
R572	Res., 8.2 k, 1 W, 2 %	74242-0500
R573	Res., 100, 1/4 W 5 %	74253-0080
R574	Res., var, 500, (TR 10 KB 500Ω)	74349-0630
R575	Res., var, 2 k (type 7246, 2 kΩ-2606)	74341-0210
R576	Same as R574	
R577	Res., 1.2 k, 1/4 W, 5 %	74253-0390
R578	Same as R573	
R579	Res., 22 k, 1/4 W, 5 %	74253-1200
R580	Res., 15 k, 1/4 W, 5 %	74253-1180
R581	Res., 4.7 k 1/4 W, 5 %	74253-0130
R582	Res., 1 k, 1/4 W, 5 %	74253-0500
R583	Res., 3.3 k,1/4 W, 5 %	74253-1070
R584	Res., 180, 1/4 W, 5 %	74253-0890
R585	Res., 1.5 k, 1/4 W, 5 %	74253-0540
R586	Res., 91, 1/4 W, 5 %	74253-0840
R587	Res., 47, 1/4 W, 5 %	74253-0070
R589	Res., 100, 1/2 W, 2 %	74241-0200
R590	Res., 10, 1/4 W, 5 %	74253-0440
R591	Same as R590	
D571	Diode SD 11F	74040-2080
D572	Diode 1S 1760	74040-2900
D573	Diode RD 7A	74040-0830
TR571	Transistor MD 3250A	74030-5070
TR572	Transistor 2N 4121	74030-2990
TR573	Transistor 2N 4275	74030-3160

A & B TIMING SWITCH

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C481	Cap., elect, 47 μF, 16 V	74120-3090
C483	Cap., cer, 10 pF, 500 V	74050-0420
C490	Cap., cer, 0.01 μF, 25 V	74060-0560
C497A	Same as C483	
C497B	Cap., cer, 100 pF, 500 V	74050-0690
C497C	Cap., poly, 0.0022 μF, 500 V	74130-1960
C497D	Cap., poly, 0.022 μF, 500 V	74130-2560
C497E	Cap., poly, 0.001 μF, 630 V	74130-3290
C497F	Cap., poly, 0.22 μF, 50 V	74130-2330
C497G	Cap., elect, 1.0 μF, 25 V	74120-2730
C498A	Cap., cer, var, 20 pF	74110-0100
C498B	Cap., cer, 27 pF, 500 V	74050-0500
C499A	Same as C498A	
C499B	Cap., cer, 39 pF, 500 V	74050-2360
C499C	Same as C498A	
C499D	Same as C499B	
C499E	Cap., mica, 950 pF, $^{+0}_{-2}$%, 300 V	74090-4680
C499F	Cap., poly, 0.01 μF, ± 1 %, 50 V	74130-1760
C499G	Cap., poly, 0.1 μF, $^{+0}_{-2}$ %, 50 V	74130-1770
C499H	Cap., poly, 1 μF, $^{+0}_{-2}$%, 50 V	74130-1780
C499J	Cap., poly, 10 μF, $^{+0}_{-2}$%, 30 V	74130-1790
C681	Same as C481	
C683	Same as C483	
C697A	Same as C483	
C697B	Same as C497B	
C697C	Same as C497C	
C697D	Same as C497D	
C697E	Same as C497E	
C697F	Same as C497E	
C698A	Same as C498A	
C698B	Same as C498B	
C699A	Same as C498A	
C699B	Same as C499B	
C699C	Same as C498A	
C699D	Same as C499B	
C699E	Same as C499E	
C699F	Same as C499F	
C699G	Same as C499G	
C699H	Same as C499H	
R481	Res., 3.9 k, 2 W, 2 %	74243-0470
R482	Res., 13 k, 1/2 W, 2 %	74241-0680
R483	Res., 10 k, 1/4 W, 5%	74253-1160
R484	Res., 24 k, 1/4 W, 5 %	74253-1210
R485, S485	Res., var, 5 k (RV 24 YN 15SB 5 kΩME(R))	74325-2330
R486	Res., var, 10 k (TR 10 KB 10 kΩ)	74349-0660
R487	Res., 300, 1/4 W, 5 %	74253-0940
R490	Res., 12 k, 1/4 W, 5 %	74253-1170
R492	Res., 100 k, 1/4 W, 5 %	74253-1290
R494	Same as R492	
R495	Same as R492	
R496	Res., 1 k, 1/2 W, 2 %	74241-0440
R497A	Res., 39 k, 1/2 W, 2 %	74241-0790
R497B	Res., 47 k, 1/2 W, 2 %	74241-0810
R497C	Res., 68 k, 1/2 W, 2 %	74241-0850
R497D	Res., 120 k, 1/2 W, 2 %	74241-0910
R497E	Res., 200 k, 1/2 W, 2 %	74241-0960
R497F	Res., 390 k, 1/2 W, 2 %	74241-1030
R497G	Res., 1 M, 1/2 W, 2 %	74241-1130
R497H	Res., 3.3 M, 1/4 W, 5 %	74281-0170
R498	Res., 4 k, 1/2 W, 1 %	74226-2260
R499A	Res., 3 k, 1/2 W, 1 %	74226-2370
R499B	Res., 11 k, 1/2 W, 1 %	74226-2380
R499C	Res., 35 k, 1/2 W, 1 %	74226-2390
R499D	Res., 31 k, 1/2 W, 1 %	74226-2280
R499E	Res., 66 k, 1/2 W, 1 %	74226-2290
R499F	Res., 171 k, 1/2 W, 1 %	74226-2300
R499G	Res., 346 k, 1/2 W, 1 %	74226-2310
R499H	Res., 696 k, 1/2 W, 1 %	74226-2320
R499J	Res., 1,746 M, 1/2 W, 1 %	74226-2330
R499K	Res., 3.5 M, 1/2 W, 1 %	74226-2340
R499L	Res., 7 M, 1/2 W, 1 %	74226-2360
R499M	Res., 10.5 M, 1/2 W, 1 %	74226-2350
R681	Same as R481	
R682	Same as R482	
R683	Same as R483	
R684	Same as R484	
R685, S685	Res., var, 5 k (RV 24 YN 15 SB 5 kΩME(R))	74325-2320
R686	Same as R486	
R687	Same as R487	
R697A	Same as R497A	
R697B	Same as R497B	
R697C	Same as R497C	
R697D	Same as R497D	
R697E	Same as R497E	
R697F	Same as R497F	
R697G	Same as R497G	
R697H	Same as R497H	
R698	Same as R498	
R699A	Same as R499A	
R699B	Same as R499B	
R699C	Same as R499C	
R699D	Same as R499D	
R699E	Same as R499E	
R699F	Same as R499F	
R699G	Same as R499G	
R699H	Same as R499H	
R699J	Same as R499J	
R699K	Same as R499K	
R699L	Same as R499L	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R699M	Same as R499M	
D490	Diode SD 104	74040-1160
TR481	Transistor 2N 4275	74030-3160
TR482	Transistor 2SC 511-0	74030-2320
TR681	Same as TR481	
TR682	Same as TR482	
S490A	Switch S43P(30) 6-7-27/S43P(30) 6-6-24/RVC	74431-5380
S490B	Same as S490A	
NE490	Neon lamp NE-2	74120-1110
NE491	Same as NE490	

HORIZ PREAMP.

C700	Cap., cer, var, 8 pF	74110-0070
C701	Cap., cer, 0.01 μF, 25 V	74060-0560
C702	Same as C701	
C703	Same as C701	
C704	Same as C701	
C705	Same as C701	
C706	Cap., poly, var, 3 p	74110-0210
C707	Cap., cer, 18 pF, 50 V	74050-3060
C708	Same as C701	
C709	Same as C701	
C710	Same as C701	
C711	Same as C701	
C720	Cap., elect, 100 μF, 25 V	74120-0880
C721	Cap., elect, 47 μF, 25 V	74120-2250
C722	Cap., elect, 33 μF, 25 V	74120-3080
C723	Same as C721	
L700	Ferrit, L, RH 03 x 03 x 03	74560-0090
R700	Res., 5.1 k, 1/2 W, 2 %	74241-0590
R701	Res., 30 k, 1/4 W, 5 %	74253-1220
R702	Res., 3.3 k, 1/4 W, 5 %	74253-1070
R703	Res., 33 k, 1/4 W, 5 %	74253-1230
R704	Res., var, 10 k (TR 10 KB 10 kΩ)	74349-0660
R705	Same as R702	
R706	Same as R701	
R707	Same as R702	
R708	Same as R701	
R709	Res., 12 k, 1/4 W, 5 %	74253-1170
R710	Res., 200 k, 1/4 W, 5 %	74253-1340
R711 a, b	Res., var, 10 k, 50 k (RV24 YD(3) 31 B 10 kΩ50 kΩ(9))	74325-2190
R712	Res., 5.1 k, 1/4 W, 5 %	74253-1100
R713	Same as R704	
R714	Res., 100, 1/4 W, 5 %	74253-0080
R715	Res., 3 k, 1/4 W, 5 %	74253-1060
R716	Res., 27, 1/4 W, 5 %	74253-0050
R717	Same as R712	
R718	Res., var, 5 k (TR 10 KB 5 kΩ)	74349-0620
R719	Res., 20 k, 1/2 W, 2 %	74241-0720
R720	Res., 1.8 k, 1/2 W, 2 %	74241-0480
R721	Res., 1 k, 1/4 W, 5 %	74253-0500
R722	Res., var, 2 k (TR 10 KB 2 kΩ)	74349-0880
R723	Same as R714	
R724	Same as R712	74253-1100
R725	Res., 15 k, 1/4 W, 5 %	74253-1180
R726	Same as R712	
R727	Same as R714	74253-0080
R728	Res., 4.7 k, 1/4 W, 5 %	74253-0130
R729	Res., 200, 1/4 W, 5 %	74253-0370
R730	Res., 100 k, 1/4 W, 5 %	74253-1290
R740	Res., 10, 1/4 W, 5 %	74253-0440
R741	Same as R740	
D700	Doide 1S 1458	74040-2920
D701	Same as D700	
D702	Same as D700	
D703	Same as D700	
D704	Same as D700	
D705	Same as D700	
D706	Same as D700	
D707	Same as D700	
D708	Same as D700	
D709	Same as D700	
D710	Same as D700	
D711	Diode RD 6A	74040-0790
D712	Same as D711	
D713	Diode 1N 750A	74040-3310
TR700	Transistor 2N 4258	74030-3100
TR701	Same as TR700	
TR702	Transistor 2N 4275	74030-3160
J700	Connector 26-190-24	74500-0440
P700	Connector 26-159-24	74500-0430
NE700	Neon lamp NE-2	74020-1110

HORIZ MAIN AMP.

C750	Cap., cer, 270 pF, 50 V	74050-0760
C751	Cap., cer, var, 45 pF	74110-0610
C752	Cap., cer, 0.01 μF, 25 V	74060-0560
C753	Cap., poly, var, 4 pF,	74110-0220
C754	Same as C753	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C755	Same as C752	
C756	Cap., cer, 0.01 μF, 500 V	74060-0730
C757	Cap., cer, 0.0047 μF, 500 V	74060-0770
C758	Same as C757	
C759	Same as C757	
C760	Same as C757	
C762	Same as C756	
C763	Same as C752	
C764	Cap., elect, 22 μF, 160 V	74120-1610
C766	Cap., elect, 10 μF, 250 V	74120-0730
C770	Cap., elect, 10 μF, 25 V	74120-0830
C771	Same as C770	
C772	Same as C757	
C773	Same as C757	
L750	Ferrit L, RH 03 x 03 x 01	74560-0090
L751	Same as L750	
R750	Res., 27, 1/2 W, 2 %	74241-0070
R751	Res., 1.6 k, 2 W, 2 %	74243-0380
R752	Res., 750, 1/2 W, 2 %	74241-0410
R753	Res., 6.2 k, 1/2 W, 2 %	74241-0610
R754	Res., 200, 1/2 W, 2 %	74241-0270
R755	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R756	Res., 4.7 k, 2 W, 2 %	74243-0490
R757	Res., 2.4 k, 1/2 W, 2 %	74241-0510
R758	Res., var, 1 k (TR 10 KB 1 kΩ)	74349-0640
R759	Res., var, 500 (TR 10 KB 500 Ω)	74349-0630
R760	Res., 220, 1/2 W, 2 %	74241-0280
R761	Res., 2.2 k, 1/2 W, 2 %	74241-0500
R762	Res., 1.2 k, 1/2 W, 2 %	74241-0450
R763	Res., 1.5 k, 1/2 W, 2 %	74241-0460
R764	Res., 300, 1/2 W, 2 %	74241-0310
R765	Same as R764	
R766	Res., 3.3 k, 1/2 W, 2 %	74241-0540
R767	Res., 4.3 k, 1/2 W, 2 %	74241-0570
R768	Res., 3.9 k, 1/2 W, 2 %	74241-0560
R769	Res., 2 k, 10 W 5 %	74220-0130
R770	Res., 20, 1/2 W, 2 %	74241-0040
R771	Res., 3 k, 1/2 W, 2 %	74241-0530
R772	Res., 47, 1/2 W, 2 %	74241-0120
R774	Same as R769	
R775	Res., 22, 1/2 W, 2 %	74241-0050
R776	Same as R767	
R777	Same as R768	
R778	Res., 300, 2 W, 2 %	74243-0230
R779	Res., 9.1 k, 1/2 W, 2 %	74241-0650
R780	Res., 15 k, 1/2 W, 2 %	74241-0690
R781	Res., 5.6 k, 1/2 W, 2 %	74241-0600
R790	Res., 10, 1/2 W, 2 %	74241-0010
R791	Same as R790	
R792	Same as R790	
R793	Same as R790	
D750	Diode HW 20A	74040-3070
D751	Same as D750	
D752	Same as D750	
D753	Same as D750	
D754	Same as D750	
D755	Diode RD 29B	74040-0970
D756	Diode 1S 955	74040-1840
D757	Same as D756	
D758	Diode 1N 754A	74040-3520
D759	Same as D756	
D760	Same as D756	
D761	Diode HW 36A	74040-3270
D762	Same as D750	
D764	Diode RD 9A	74040-0840
TR750	Transistor TA 2761	74030-3170
TR751	Transistor 2N 4275	74030-3160
TR752	Same as TR750	
TR753	Same as TR751	
TR754	Same as TR751	
TR755	Transistor 2N 4121	74030-2990
TR756	Transistor 2N 3635	74030-3200
TR757	Same as TR751	
TR758	Transistor 2N 3500	74030-3210
TR759	Transistor 2SC 511-0	74030-2320
TR760	Transistor 2SC 154C	74030-4000
TR761	Same as TR751	
J750	Connector 143-015-01	74500-1900

Z AXIS AMPLIFIER

C800	Cap., cer, var, 60 pF, 250 V	74110-1000
C801	Cap., cer, var, 7pF, 250 V	74110-0660
C802	Cap., cer, var, 1.5 pF, 500 V	74110-0290
C803	Cap., cer, 0.0022 μF, 500 V	74060-0840
C804	Cap., cer, 0.01 μF, 500 V	74060-0730
C805	Cap., cer, 8 pF, 500 V	74050-3650
C806	Same as C804	
C807	Cap., cer, 0.01 μF, 50 V	74060-0580
C808	Same as C807	
C809	Cap., cer, 47 pF, 50 V	74050-2730
C810	Cap., cer, 27 pF, 50 V	74050-5760
C811	Cap., cer, 150 pF, 50 V	74050-3010
C812	Cap., cer, 0.0068 μF, 2 kV	74060-1980
C813	Same as C812	
C814	Same as C805	
C815	Same as C805	
C816	Cap., cer, 18 pF, 500 V	74050-3960
C817	Cap., cer, 0.005 μF, 3 kV	74060-2010

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C818	Cap., cer, 3 pF, 500 V	74050-3870
R800	Res., 47, 1/4 W, 5 %	74230-0100
R801	Res., 620, 1/4 W, 5 %	74230-1040
R802	Res., 2.4 k, 1/4 W, 5 %	74230-0220
R803	Res., 510, 1/4 W, 5 %	74230-0450
R804	Same as R800	
R805	Res., 10, 1/4 W, 5 %	74230-0070
R806	Res., 1 k, 1/4 W, 5 %	74230-0030
R807	Res., 680 k, 1/4 W, 5 %	74230-0150
R808A	Res., 750 k, 1/4 W, 5 %	74230-0540
R808B	Res., 500, 1/4 W, 2 %	74349-0720
R809	Res., 1.5 k, 1/4 W, 5 %	74230-0110
R810	Res., 10 k, 1/2 W, 2 %	74241-0660
R811	Res., 100, 1/4 W, 5 %	74230-0130
R812	Same as R805	
R813	Same as R802	
R815	Same as R806	
R816	Res., 9.1 k, 1/4 W, 5 %	74230-1090
R817	Res., 100 k, 1/4 W, 5 %	74230-0260
R818	Same as R807	
R819	Same as R805	
R820	Res., 20 k, 1/4 W, 5 %	74230-0310
R821	Same as R820	
R822	Same as R820	
R823	Same as R820	
R824	Same as R820	
R825	Same as R820	
R826	Same as R809	
R827	Same as R805	
R828	Res., 4.7 k, 1/4 W, 5 %	74230-0290
R829	Same as R811	
R830	Same as R806	
R831	Same as R806	
R832	Same as R806	
R833	Same as R806	
R835	Same as R817	
R836	Res., 27 k, 1/4 W, 5 %	74230-0390
R837	Res., 5 k, 1/4 W, 2 %	74349-1670
R838	Res., 20 k, 1/2 W, 2 %	74241-0720
R839	Same as R805	
R840	Same as R805	
R841	Same as R805	
R842	Same as R805	
R843	Same as R805	
R844	Res., 47 k, 1/2 W, 2 %	74241-0810
R845	Res., 3.3 M, 1/4 W, 2 %	74253-0310
R846	Same as R838	
D800	Diode 1S953	74040-1720
D801	Diode RD6A (N)	74040-4450
TR800	Transistor 2N4275	74030-3160
TR801	Transistor 2N4121	74030-2990
TR802	Same as TR800	
TR803	Same as TR801	
TR804	Transistor 2SA565B	74030-3910
TR805	Same as TR804	
TR806	Same as TR804	
TR807	Same as TR804	
TR808	Same as TR804	
TR809	Same as TR804	
TR810	Transistor 2SC154C	74030-4000
TR811	Same as TR800	
TR812	Same as TR800	
TR813	Transistor 2N4258	74030-3150
TR814	Same as TR813	
J800	Connector UG-625/V-Ni	74500-2530

CRT CIRCUIT

C900	Cap., elect, 0.68 μF, 25 V	74120-3860
C901	Cap., 0.015 μF, 25 V	74060-1960
C902	Same as C901	
C903	Cap., poly, 0.1 μF, 200 V	74130-3280
C904	Same as C901	
C905	Cap., elect, 1.7 μF, 125 V	74120-4350
C906	Cap., cer, 0.001 μF, 10 KV	74060-2160
C907	Same as C906	
C908	Same as C906	
C909	Same as C906	
C910	Cap., cer, 500 pF, 20 k	74060-2080
C913	Cap., cer, 0.01 μF, 500 V	74060-1130
C914	Same as C913	
C915	Same as C913	
C916	Cap., elect, 60 μF, 50 V	74120-4350
C917	Same as C901	
C918	Same as C913	
C919	Cap., cer, 0.001 μF, 500 V	74060-0700
C920	Same as C919	
C921	Same as C919	
R900	Res., var, 100 k (TR 10 KB 100 kΩ)	74349-0650
R901	Res., 1.8 M, 1/4 W, 5 %	74281-0020
R902	Res., 10 k, 1/4 W, 5 %	74230-0120
R903	Res., 1.2 k, 1/4 W, 5 %	74230-0500
R904	Res., 1.2 M, 1/4 W, 5 %	74281-0180
R905	Res., 17 M, 2 W, 6 kV ± 10 %	74256-0090
R906	Res., 100, 1/4 W, 5 %	74230-0130
R907	Res., 100 k, 1/4 W, 5 %	74230-0260
R908	Same as R907	
R909	Res., 33 k, 1/2 W, 2 %	74241-0770
R910	Res., 1 k, 1/2 W, 2 %	74241-0440

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R911	Res., var, 100 k, (RV 24 YN 12 SB 100 kΩ)	74325-2310
R912	Same as R909	
R913	Res., 10 k, 1/4 W, 5 %	74281-0330
R914	Res., 1 M, 1/4 W, 5 %	74281-0340
R915	Res., 6.8 M, 1 W, 5 %	74283-0170
R916	Res., var, 5 M (RV 16 YN 33 RB 5 MΩ)	74322-0750
R917	Res., 13 M, 2 W, 6 kV ± 10 %	74256-0080
R918	Res., 15 M, 2 W, 6 kV ± 10 %	74256-0070
R919	Res., var, 2 M, (RV 16 YN 33 RB 2 MΩ)	74322-1780
R920	Res., 4.7 k, 1/4 W, 5 %	74230-0290
R921	Res., var, 2 k (HR 121 10 SB 2 kΩ)	74331-0430
R922	Res., var, 2 k (HR 133-2 kΩ)	74331-0380
R923	Same as R922	
R924	Res., var, 200 k (RV 24 YN 12 SB 200 kΩ)	74325-2350
R925	Same as R924	
R926	Res., var, 100 k (EVSV 2AS10 B15)	74345-0250
R927	Res., 22 k, 1/4 W, 5 %	74230-0320
R928	Res., 47 k, 1/4 W, 5 %	74230-0170
R931	Res., 200, 1/2 W, 2 %	74241-0270
R932	Same as R931	
R934	Res., 3.3 M, 1/4 W, 5 %	74281-0170
D900	Diode HF SD-1	74040-3140
D901	Diode VF5–5X	74040-3570
D902	Same as D901	
D903	Diode VF5–12X	74040-3560
D904	Same as D903	
D905	Same as D903	
D906	Same as D903	
D907	Diode HW 43A	74040-3300
TR900	Transistor 2SC 350 H	74030-1990
TR901	Transistor 2N 4121	74030-2990
TR902	Transistor 2SC 513-0	74030-3740
TR903	Transistor 2SD 93	74030-3760
F900	Fuse 1A	74540-0060
NE900	Neon lamp NE-68	74020-1170
NE901	Same as NE900	
NE902	Same as NE900	
T900	Transformer FS-23923 ②	74472-0852
V900	CRT D13-45 GH	74010-0810
	CRT anode cap FS-11972	74480-0220
	CRT side-pin cap FS-17434	74480-0280

POWER SUPPLY

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
C1000	Cap., elect, 15 μF, 75 V	74120-4360
C1001	Cap., elect, 47 μF, 25 V	74120-1390
C1002	Cap., elect, 100 + 100 μF, 150 V	74120-2560
C1003	Cap., poly, 0.1 μF, 200 V	74130-3280
C1004	Cap., cer, 0.01 μF, 50 V	74060-0580
C1005	Same as C1004	
C1006	Cap., cer, 0.001 μF, 500 V	74060-0700
C1007	Cap., cer, 0.01 μF, 500 V	74060-0730
C1008	Same as C1003	
C1009	Cap., elect, 22 μF, 350 V	74120-0460
C1012	Cap., elect, 470 μF, 160 V	74120-2740
C1013	Cap., elect, 11 μF, 100 V	74120-4370
C1014	Same as C1003	
C1015	Cap., cer, 0.022 μF, 50 V	74060-0660
C1017	Same as C1003	
C1019	Same as C1007	
C1020	Same as C1009	
C1023	Cap., elect, 47 μF, 50 V	74120-2970
C1024	Cap., elect, 3300 μF, 35 V	74120-2750
C1025	Cap., cer, 0.1 μF $^{+80}_{-20}$%, 25 V	74060-1130
C1026	Cap., cer, 0.001 μF, 50 V	74060-1750
C1027	Same as C1026	
C1028	Same as C1026	
C1029	Same as C1025	
C1030	Cap., elect, 100 μF, 25 V	74120-1030
C1033	Same as C1024	
C1034	Cap., elect, 100 μF, 16 V	74120-3340
C1035	Same as C1004	
C1036	Same as C1025	
C1037	Same as C1025	
C1038	Same as C1025	
C1039	Same as C1030	
C1040	Same as C1006	
C1042	Cap., elect, 4.7 μF, 250 V	74120-0680
R1000	Res., 5.1 k, 1/4 W, 5 %	74230-1020
R1001	Res., 10 k, 1/4 W, 5 %	74230-0120
R1002	Res., 100 k, 1/2 W, 2 %	74241-0890
R1003	Res., 33 k, 1/4 W, 5 %	74230-0300
R1004	Same as R1001	
R1005	Res., 150 k, 1/4 W, 1 %	74221-0460
R1006	Res., 120, 1/4 W, 5 %	74230-1130
R1007	Res., 30, 5 W, 5 %	74220-0170
R1008	Res., 49.9 k, 1 W 1 %	74221-0480
R1009	Res., var, 500 (λ –13T 500Ω)	74331-0360
R1010	Res., 3.48 k, 1/8 W, 1 %	74221-0440
R1011	Res., 20, 5 W, 5 %	74220-0160
R1015	Res., 10 k, 1/2 W, 2 %	74241-0660
R1016	Res., 68 k, 1/2 W, 2 %	74241-0850

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
R1017	Same as R1002	
R1018	Res., 47, 1/4 W, 5 %	74230-0100
R1019	Res., 0.6, 2 W, 5 %	74227-0200
R1020	Same as R1003	
R1021	Same as R1001	
R1022	Res., 75 k, 1/8 W, 1 %	74221-0450
R1023	Same as R1006	
R1024	Res., 18.2 k, 1/2 W, 1 %	74221-0470
R1025	Same as R1009	
R1026	Res., 2.74 k, 1/8 W, 1 %	74221-0430
R1027	Same as R1011	
R1028	Res., 100, 5 W, 5 %	74220-0150
R1029	Same as R1028	
R1033	Res., 4.7 k, 1/2 W, 2 %	74241-0580
R1034	Same as R1015	
R1035	Res., 0.3, 5 %	74227-0160
R1036	Res., 470, 1/4 W, 5 %	74230-0160
R1037	Res., 24 k, 1/4 W, 5 %	74230-0800
R1038	Same as R1022	
R1039	Res., 200, 1/4 W, 5 %	74230-1340
R1040	Same as R1039	
R1041	Res., 27 k, 1/4 W, 5 %	74230-0390
R1042	Same as R1006	
R1043	Res., 3.74 k, 1/8 W, 1 %	74221-0410
R1044	Same as R1009	
R1045	Res., 2.94 k, 1 %	74221-0420
R1046	Res., 50, 7 W, 5 %	74220-0140
R1049	Same as R1015	
R1050	Same as R1035	
R1051	Same as R1036	
R1052	Res., 51 k, 1 W, 2 %	74242-0690
R1053	Res., 620, 1/4 W, 5 %	74230-1040
R1054	Res., 1 k, 1/4 W, 5 %	74230-0030
R1055	Res., 910, 1/4 W, 5 %	74230-1260
R1056	Res., 820, 1/4 W, 5 %	74230-0490
R1057	Res., 91, 1/4 W, 5 %	74230-1230
R1058	Same as R1057	
R1059	Same as R1041	
R1060	Same as R1006	
R1061	Res., 2.61 k, 1/8 W, 1 %	74221-0390
R1062	Same as R1009	
R1063	Res., 1.96 k, 1/8 W, 1 %	74221-0400
R1064	Same as R1046	
R1067	Res., var, 30 (RPF 10 SA 18 R 30Ωkk)	74331-0440
R1068	Res., 18 k, 1/2 W, 2 %	74241-0710
R1069	Same as R1002	
R1070	Res., 100 k, 1/4 W, 5 %	74230-0260
R1071	Res., 75 k, 1/4 W, 5 %	74230-0590
R1072	Same as R1054	
R1075	Res., 1 k, 1/2 W, 2 %	74241-0440

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
D1000	Diode HW 33A	74040-3010
D1001	Diode V 03C	74040-3350
D1002	Same as D1001	
D1003	Same as D1001	
D1004	Diode V06G	74040-4010
D1005	Same as D1004	
D1006	Same as D1004	
D1007	Same as D1004	74040-4010
D1008	Same as D1001	
D1009	Diode HW 91A	74040-3240
D1010	Diode 1S 953	74040-1720
D1012	Same as D1010	
D1013	Diode 1S 955	74040-1840
D1014	Same as D1009	
D1015	Same as D1004	
D1016	Same as D1004	
D1017	Same as D1004	
D1018	Same as D1004	
D1019	Same as D1000	
D1020	Same as D1013	
D1021	Same as D1013	
D1022	Diode HW 56A	74040-3290
D1023	Same as D1010	
D1025	Same as D1010	
D1026	Same as D1013	
D1027	Diode HW 30A	74040-3210
D1028	Same as D1001	
D1031	Same as D1001	
D1032	Same as D1001	
D1033	Same as D1001	
D1034	Same as D1001	
D1035	Same as D1010	
D1036	Diode 1S 552	74040-3220
D1037	Same as D1001	
D1038	Same as D1001	
D1039	Same as D1001	
D1040	Same as D1001	
TR1000	Transistor 2SC 513-0	74030-3740
TR1001	Transistor 2SD198	74030-4650
TR1002	Transistor 2SC 154 H -C	74030-3810
TR1003	Transistor 2SC 154 C	74030-4000
TR1004	Transistor 2SC 907 H -C	74030-3980
TR1005	Transistor 2SC 511-0	74030-2320
TR1006	Transistor 2SC 1030	74030-4660
TR1007	Same as TR1004	
TR1008	Same as TR1004	
TR1009	Same as TR1004	
TR1010	Same as TR1000	
TR1011	Same as TR1006	
TR1012	Same as TR1004	

CIRCUIT REFERENCE	DESCRIPTION	IWATSU PART No.
TR1013	Transistor μ PA-15	74030-1520
TR1014	Same as TR1004	
TR1015	Same as TR1000	
TR1016	Same as TR1006	
S1000	Switch MST 206N	74440-0150
S1001	Switch FS-20445	74450-0870
S1002	Same as S1000	
F1000	Fuse 0.5A	74540-0050
F1001	Fuse 1A	74540-0060
F1002	Fuse 3A	74540-0500
NE1000	Neon lamp NE-68	74020-1170
	Neon socket	74480-0430
T1000	Transformer FS-23918 ③	74471-1883
U1000	Power cord U-81025	74470-1350
PL1000	Lamp 6.3 V, 150 mA	74490-0150
PL1001	Same as PL1000	
	Socket E-5	74480-1310
FAN		74550-0190

CALIBRATOR

C1100	Cap., elect, 10 μF 25 V	74120-0830
C1101	Cap., elect, 10 μF, 25 V	74120-1640
C1102	Cap., cer, 0.02 μF, 25 V	74060-0570
C1103	Cap., poly, 0.1 μF ± 1 %, 100 V	74130-1830
C1104	Cap., cer, 0.05 μF, 25 V	74060-1220
C1105	Cap., cer, 470 pF, 500 V	74060-0760
C1106	Cap., cer, 100 pF, 500 V	74050-0690
R1100	Res., 10 k, 1/4 W, 5 %	74230-0120
R1101	Res., 910, 1/4 W, 5 %	74230-1260
R1102	Res., var, 500 (TR 10 k 500Ω)	74349-0630
R1103	Res., 3 k, 1/4 W, 5 %	74230-0530
R1104	Res., 47, 1/4 W, 5 %	74230-0100
R1105	Res., 470, 1/4 W, 5 %	74230-0160
R1106	Same as R1100	
R1107	Res., 2.2 k, 1/4 W, 5 %	74230-0270
R1108	Same as R1105	
R1109	Res., 7.5 k, 1/4 W, 5 %	74230-0570
R1110	Res., 1 k, 1/4 W, 1 %	74226-0010
R1111	Res., 667, 1/4 W, 1 %	74226-2110
R1112	Res., 179, 1/4 W, 1 %	74226-2120
R1113	Res., 80.1, 1/4 W, 1 %	74226-2130
R1114	Res., 45.2, 1/4 W, 1 %	74226-2140
R1115	Res., 5 k, 1/4 W, 1 %	74226-2160
R1116	Res., 21.3, 1/4 W, 1 %	74226-2170
R1117	Same as R1115	
R1118	Res., 50, 1/4 W, 1 %	74226-2180
R1119	Res., 0.25, 1/2 W	74310-1180
R1120	Res., 28.7, 1/4 W, 1 %	74226-2170
R1121	Res., 2 k, 1/2 W, 2 %	74241-0490
TR1100	Transistor 2N 4275	74030-3160
TR1101	Same as TR1100	
TR1102	Same as TR1100	
TR1103	Transistor 2N 4121	74030-2990
S1100	Rotary Switch FS-021463 ②	74431-5320
J1100	Connector BNC-RBP 2-9	74500-2360
T1100	Transformer pF-23928 ③	74472-0832

Abbreviations used in this manual are as follows:

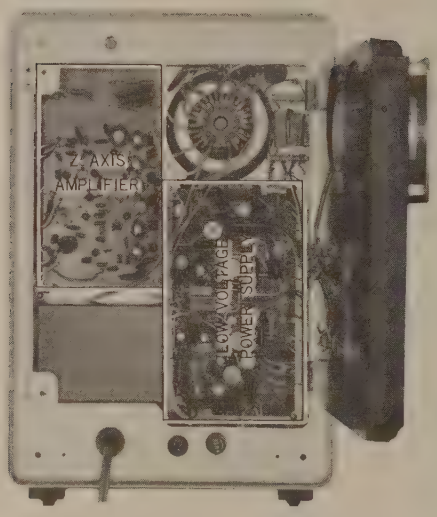
◆For units:

A	ampere
mA	milliampere
μA	microampere
nA	nanoampere(10^{-9}A)
dB	decibel
div(DIV)	division
g	gram
kg	kilogram
Hz	hertz
kHz	kilohertz
MHz	megahertz
GHz	gigahertz
m	meter
cm	centimeter
mm	millimeter
sec(SEC)	second
msec	millisecond
μsec	microsecond
n sec	nanosecond(10^{-9}sec)
p sec	picosecond(10^{-12}sec)
F	farad
μF	microfarad
pF	picofarad
V	volt
mV	millivolt
μV	microvolt
VA	voltampere
W	watt
mW	milliwatt
Ω	ohm
MΩ	megaohm
kΩ	kilohm
rms	root mean square
p-p	peak to peak

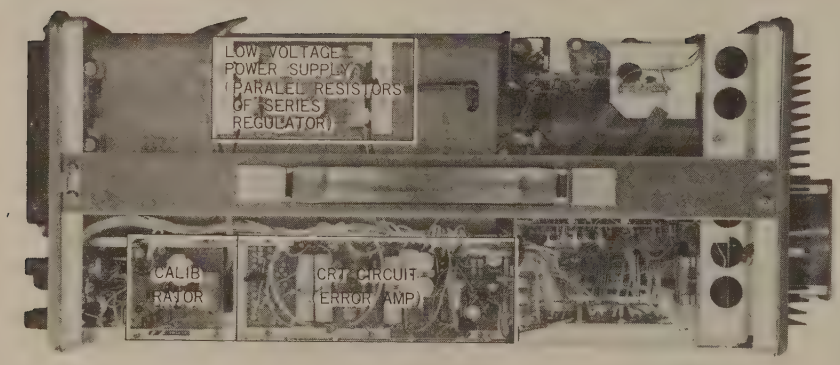
◆Others:

AC	alternate current
ADJ	adjust
ALT	alternate
ASTIG	astigmatism
AUTO(Auto)	automatic
BAL	balance
CALIB	calibrated
CAL OUT	calibrator output
CENT	center
CH 1	channel 1
CH 2	channel 2
CHOP	chopped
DC	direct current
EXT	external
GND	ground(earth)
HF REJ	high frequency reject
HORIZ	horizontal
ILLUM	illumination
INT	internal
INTEN	intensity
LF REJ	low frequency reject
MAG	magnifier
NORM	normal
SENS	sensitivity
SWP	sweep
TRIG	trigger
UNCAL	uncalibrated
VERT	vertical

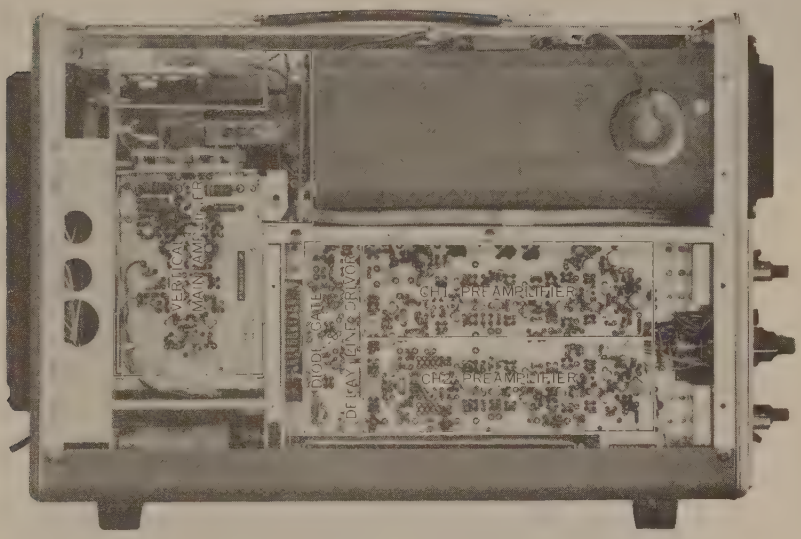
Rear View



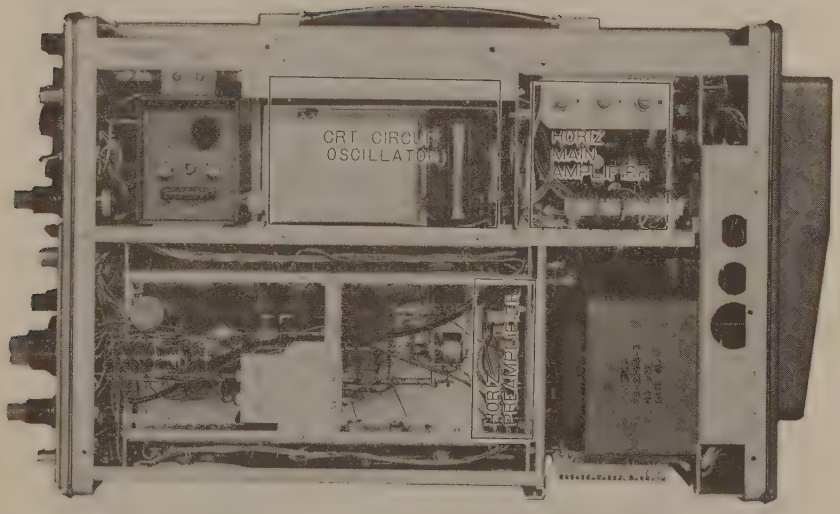
Top View



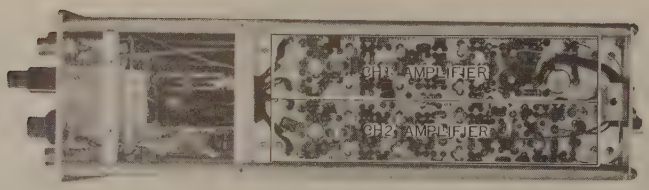
Left Side View



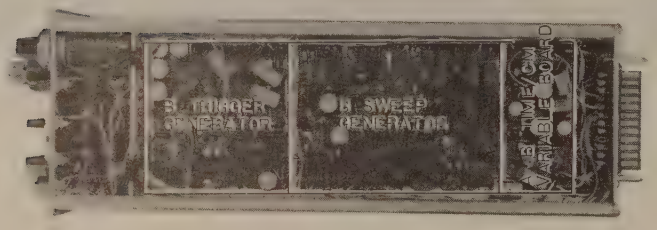
Right Side View



Vertical Plug-in Unit(Right Side View)

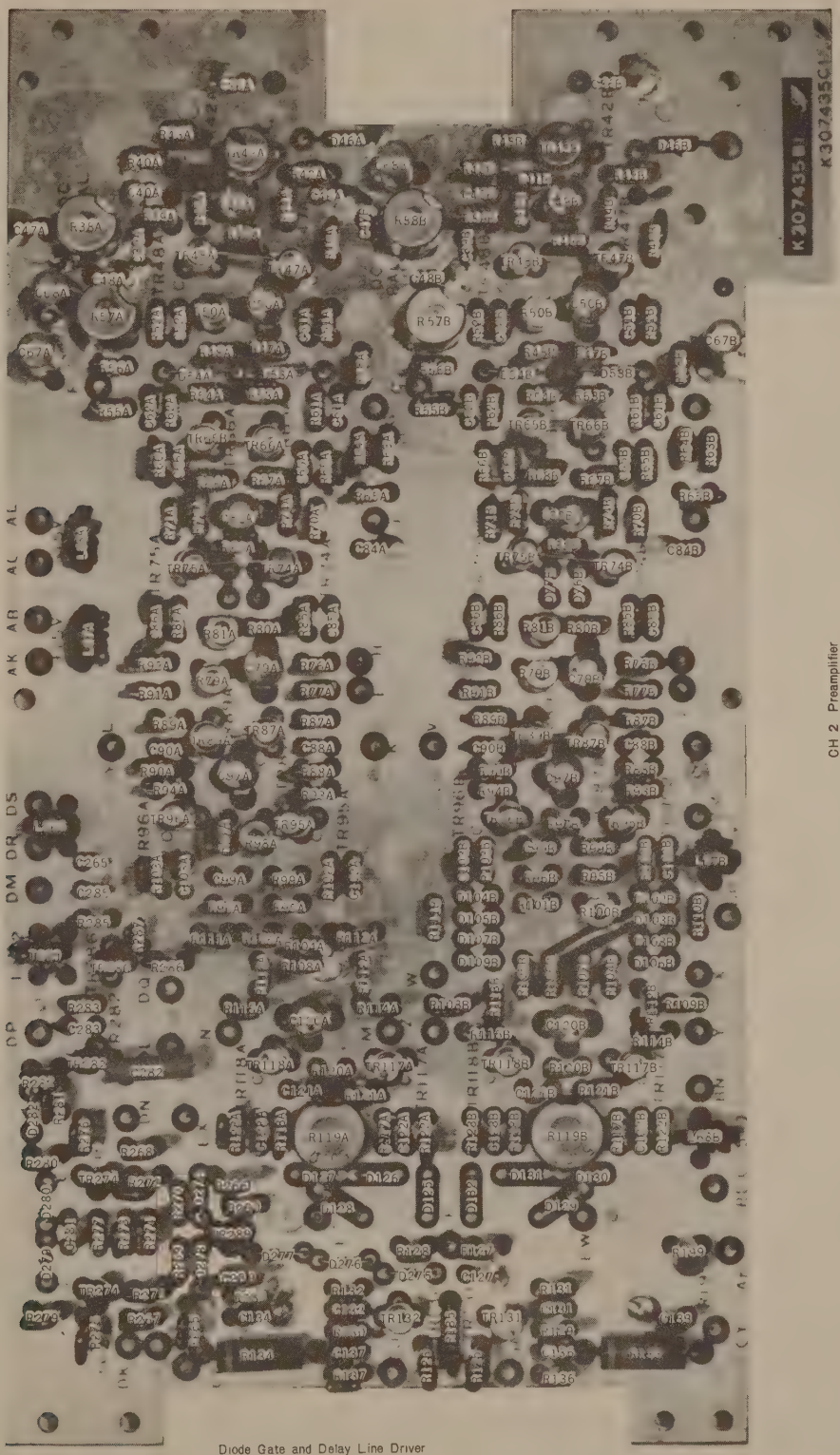


Horizontol Plug-in Unit(Top View)



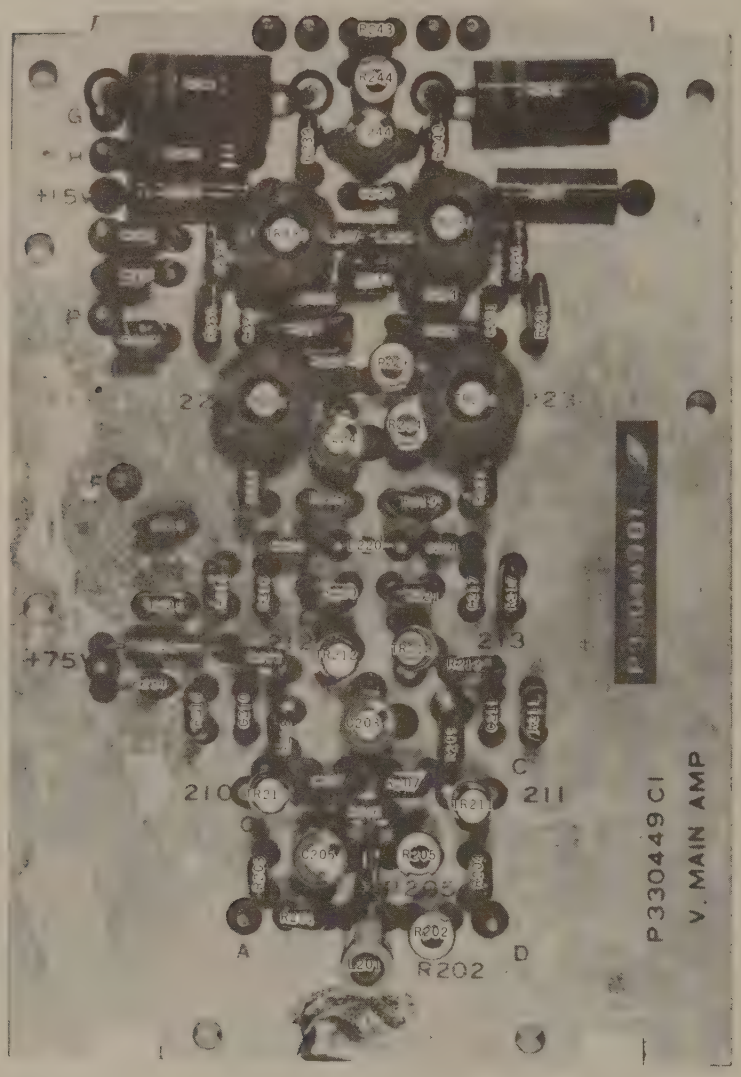
Horizontal Plug-in Unit(Bottom View)

Horizontal Plug-in Unit(Rear View)

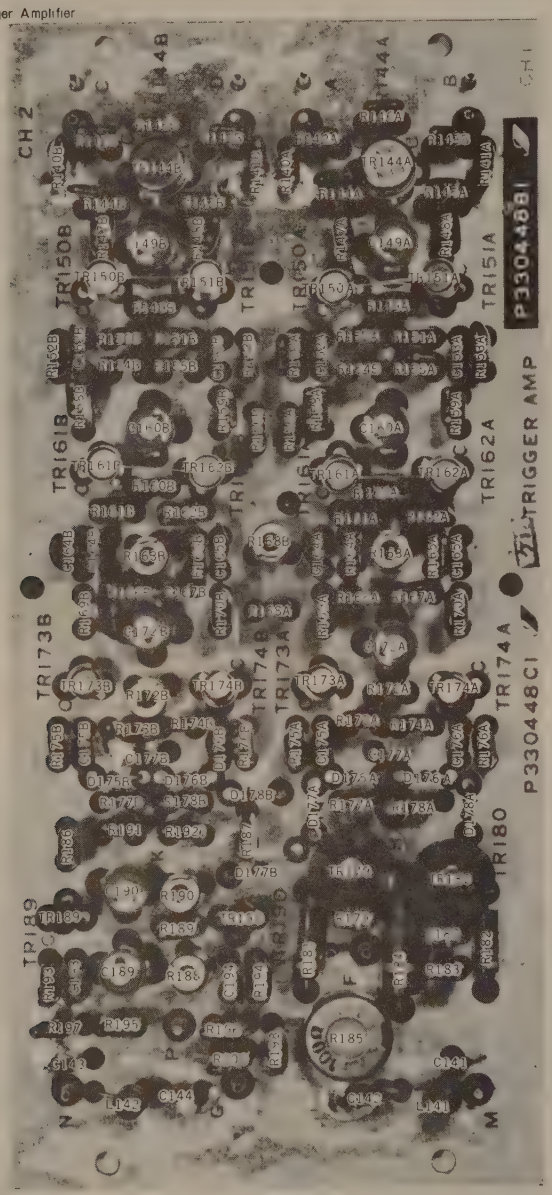


Diode Gate and Delay Line Driver

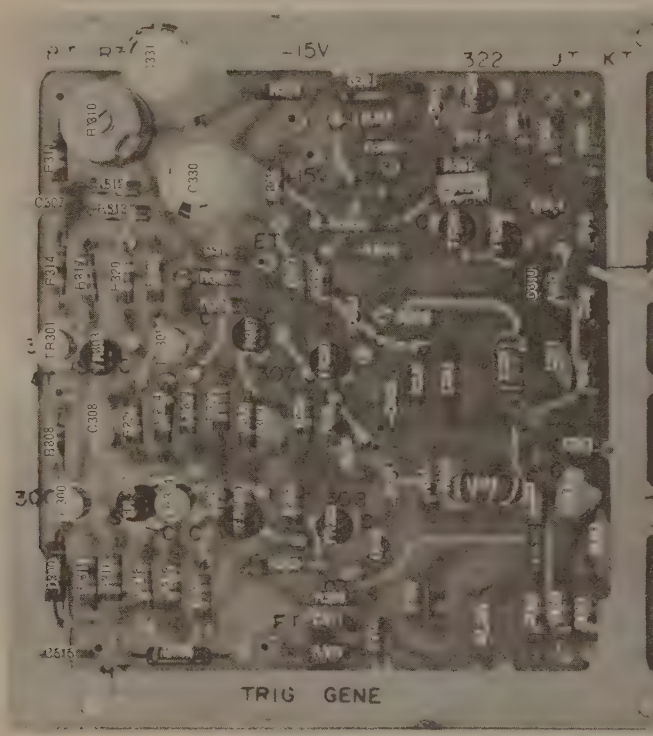
Vertical Main Amplifier



Trigger Amplifier

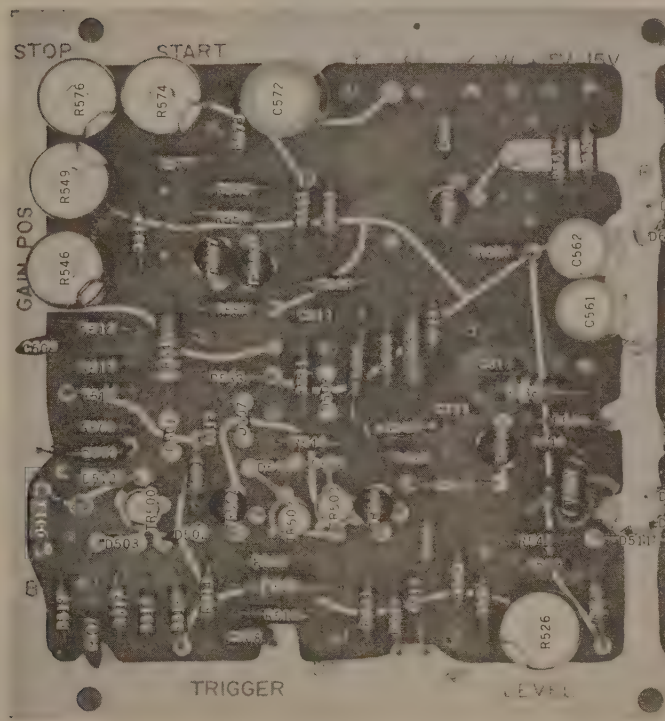


Printed Circuit Board Diagram

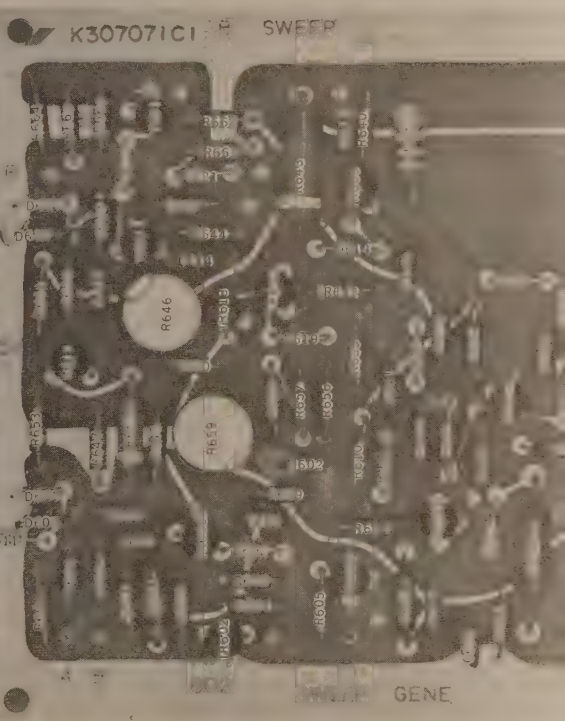


A Trigger Generator

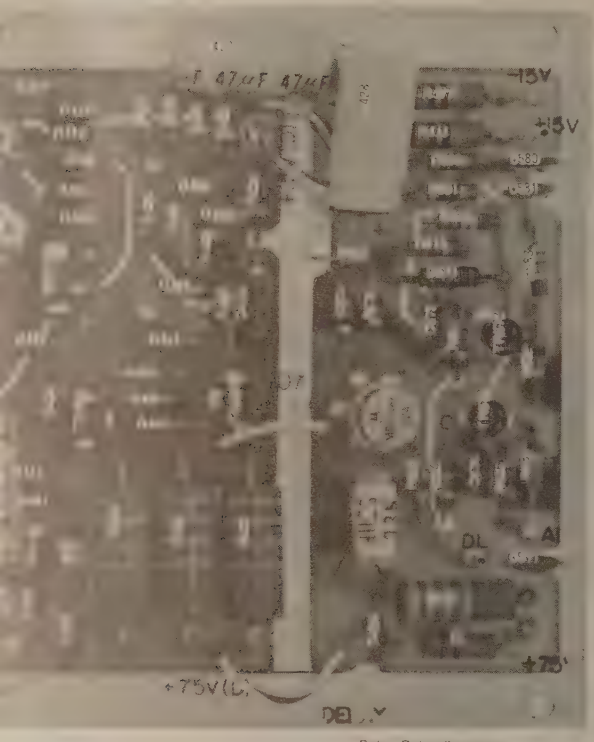
A Sawtooth Generator



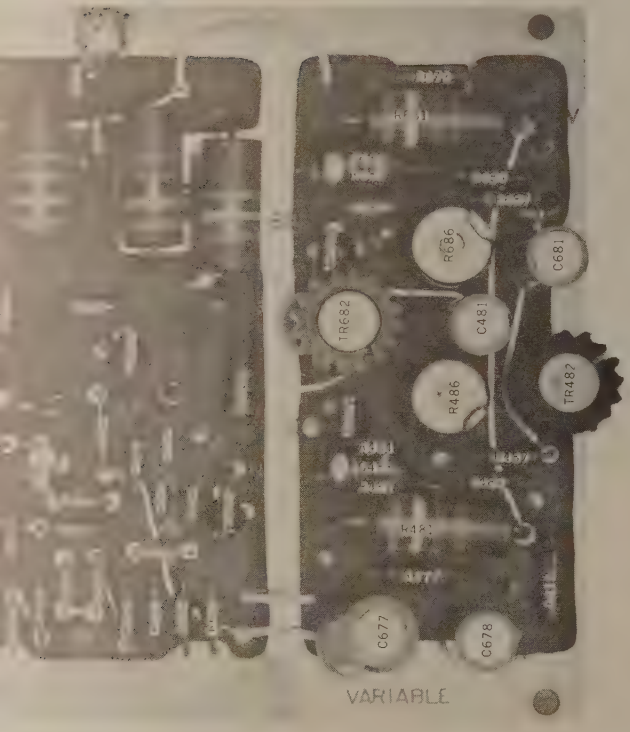
B Trigger Generater



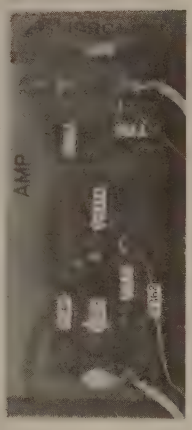
B Sawtooth Generator



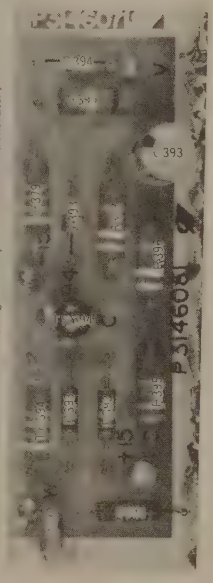
Delay Pulse Generator



VARIABLE BOARD



A Trigger Generator (Trigger Amplifier)

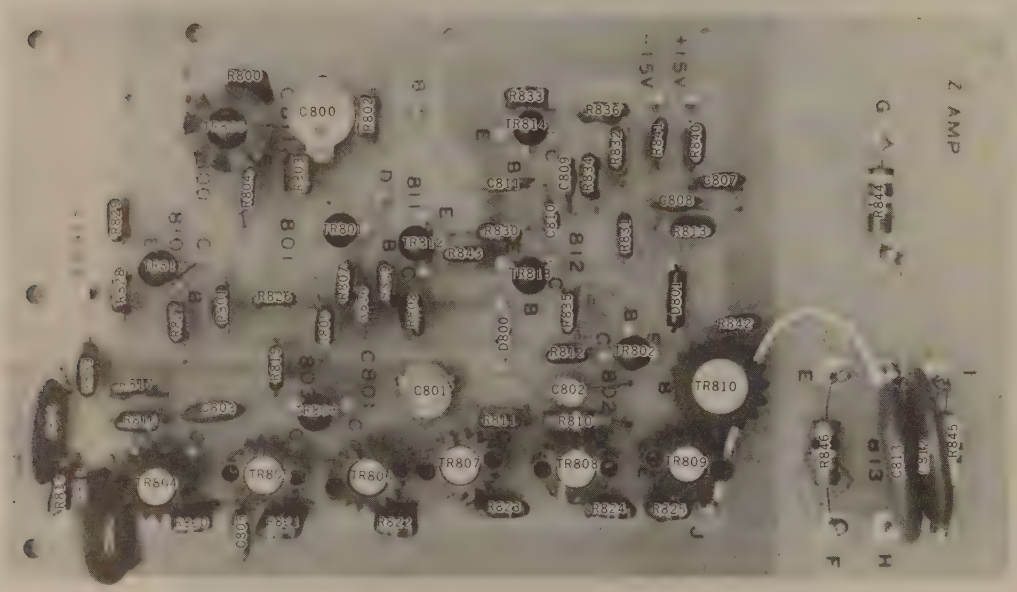


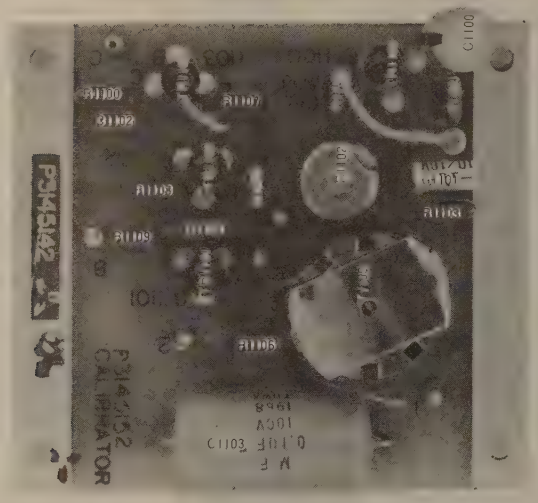
A Sawtooth Generator (Single Sweep Reset Pulse Generator)

Horizontal Preamplifier

Horizontal Main Amplifier

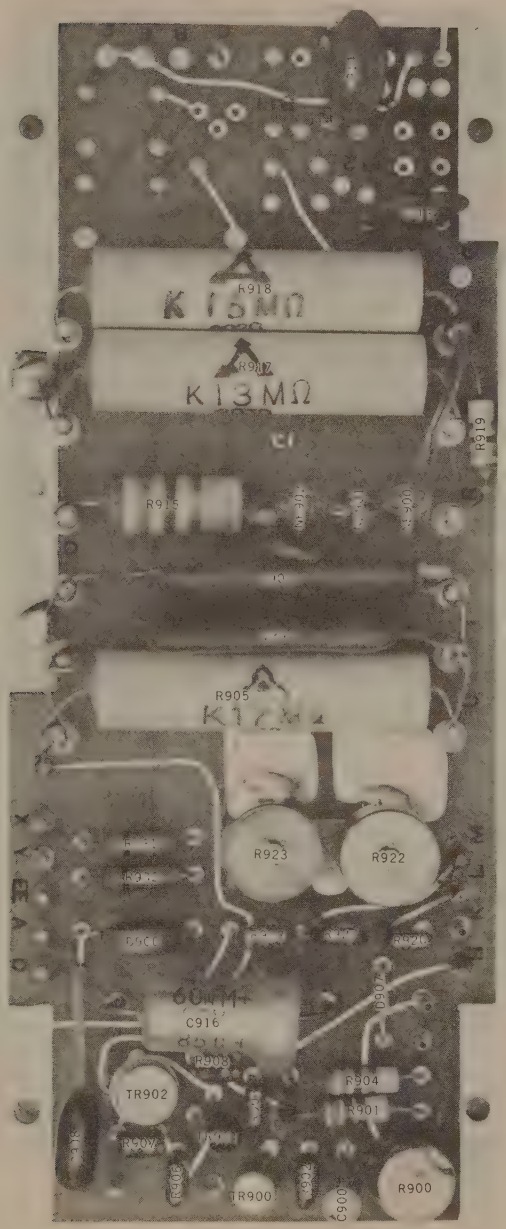
Z Axis Amplifier



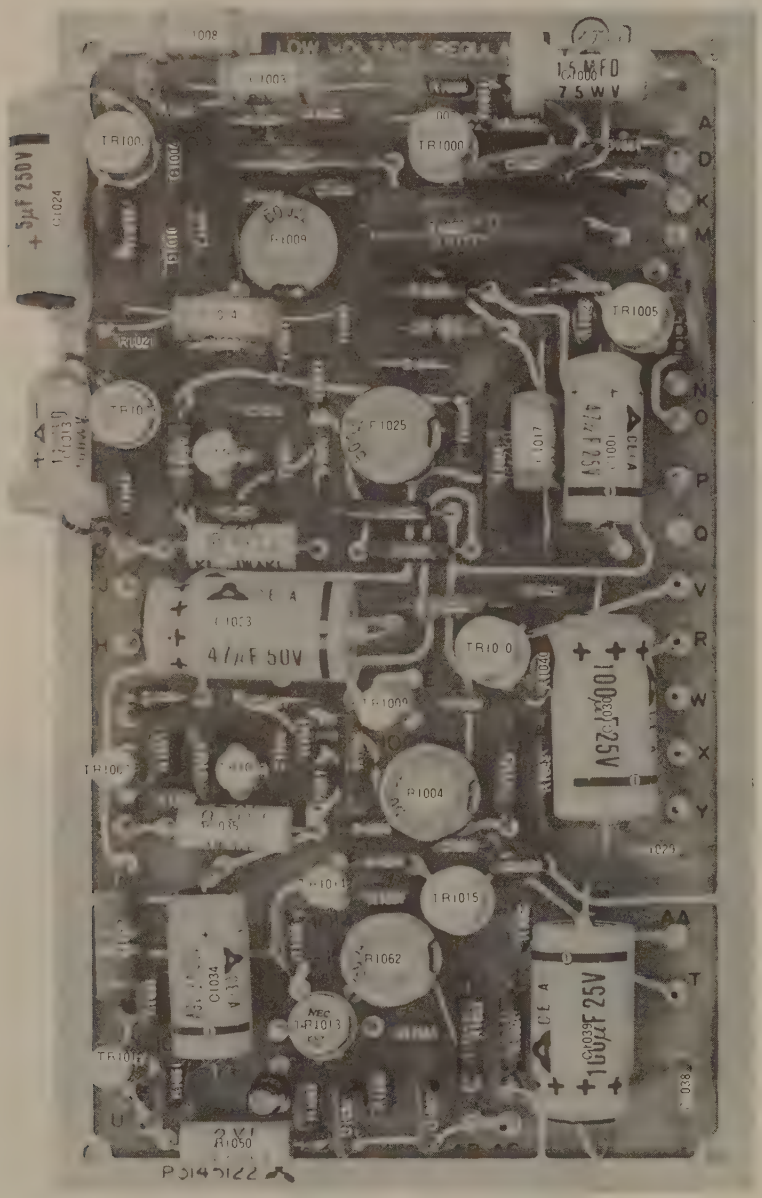


Calibrator

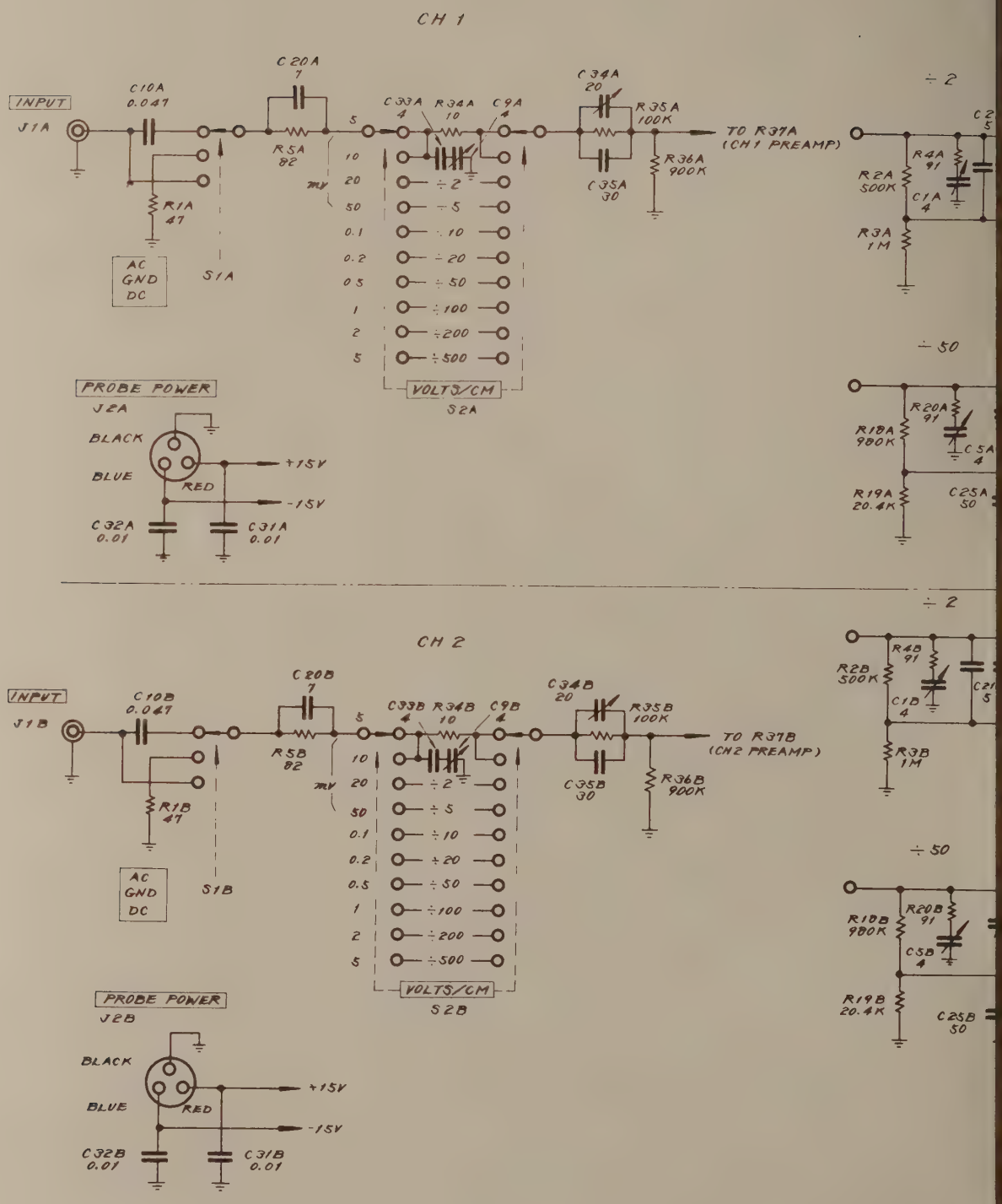
CRT Circuit (Error Amplifier)

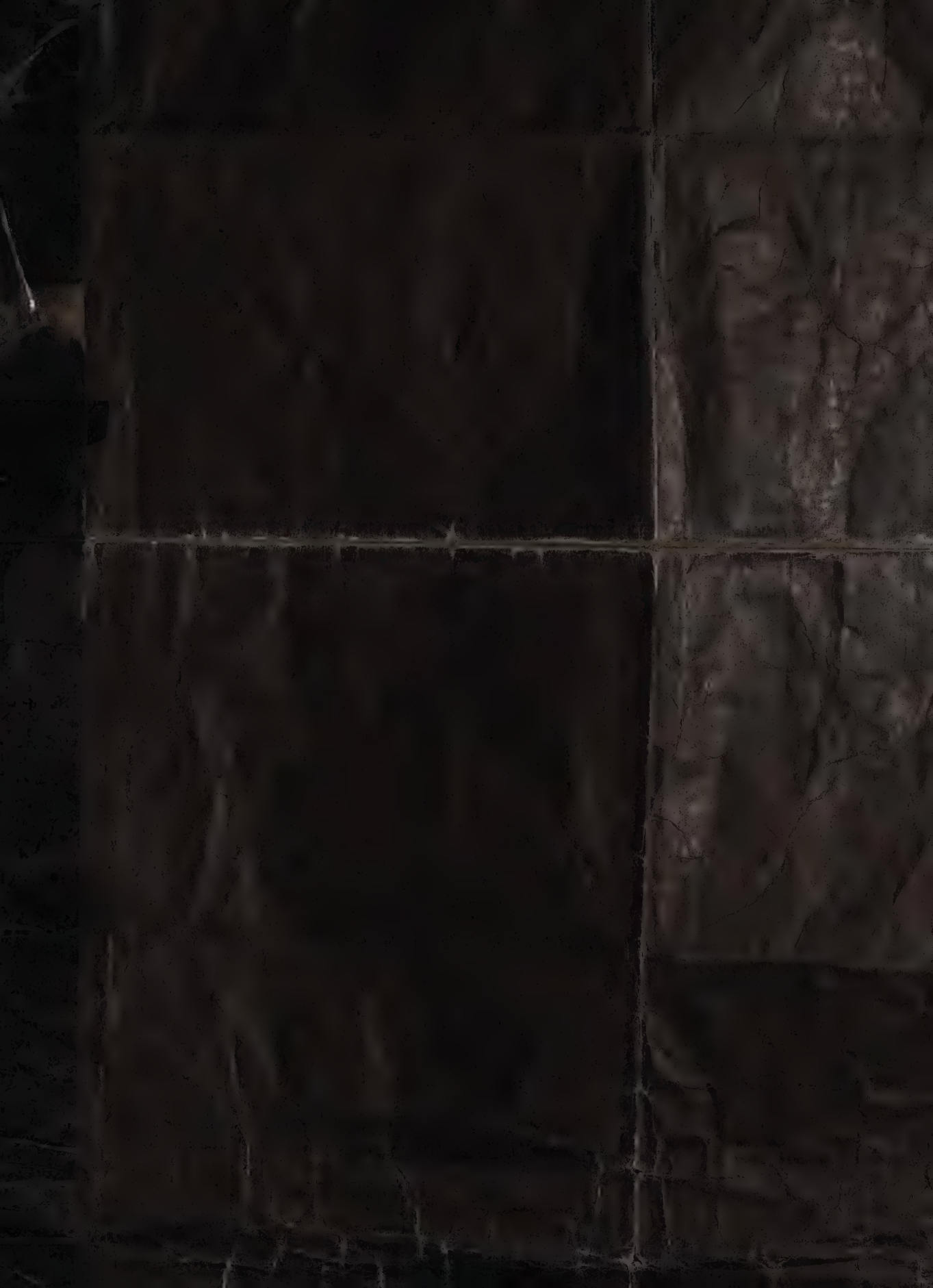


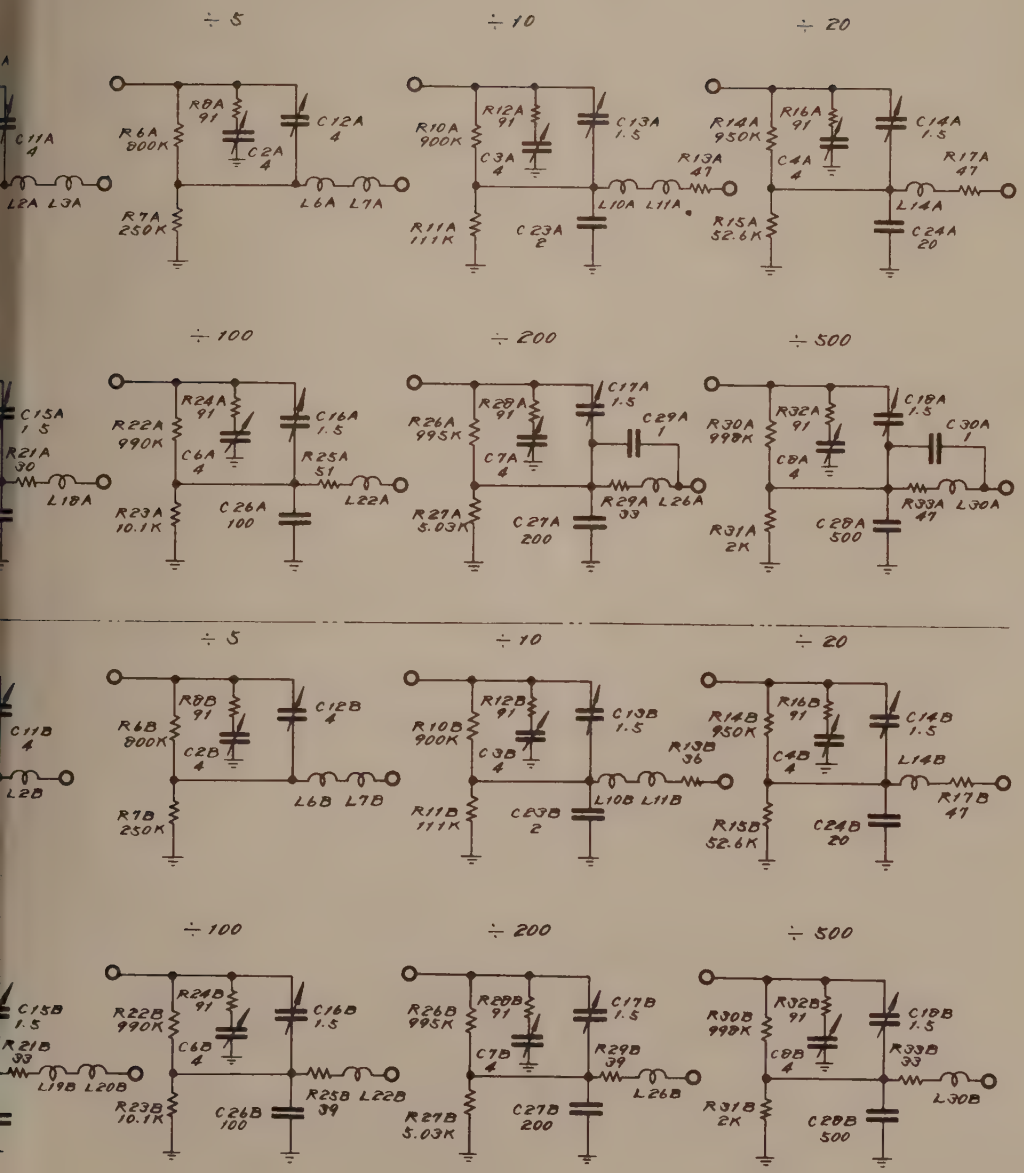
Low-Voltage Power Supply



VERTICAL INPUT & ATTENUATOR


CH 1
INPUT
J1A
C10A 0.047
C20A 7
R5A 82
C33A 4
R34A 10
C9A 4
C34A 20
R35A 100K
C35A 30
R36A 900K
TO R37A (CH1 PREAMP)
R1A 47
AC GND DC
S1A
5
10
20
50
0.1
0.2
0.5
1
2
5
mV
÷2
÷5
÷10
÷20
÷50
÷100
÷200
÷500
VOLTS/CM
S2A
÷2
R2A 500K
R4A 91
C1A 4
R3A 1M
C2 5
÷50
R18A 980K
R20A 91
C5A 4
R19A 20.4K
C25A 50
PROBE POWER
J2A
BLACK
BLUE
RED
+15V
-15V
C32A 0.01
C31A 0.01
CH 2
INPUT
J1B
C10B 0.047
C20B 7
R5B 82
C33B 4
R34B 10
C9B 4
C34B 20
R35B 100K
C35B 30
R36B 900K
TO R37B (CH2 PREAMP)
R1B 47
AC GND DC
S1B
S2B
÷2
R2B 500K
R4B 91
C1B 4
R3B 1M
÷50
R18B 980K
R20B 91
C5B 4
R19B 20.4K
C25B 50
PROBE POWER
J2B
C32B 0.01
C31B 0.01

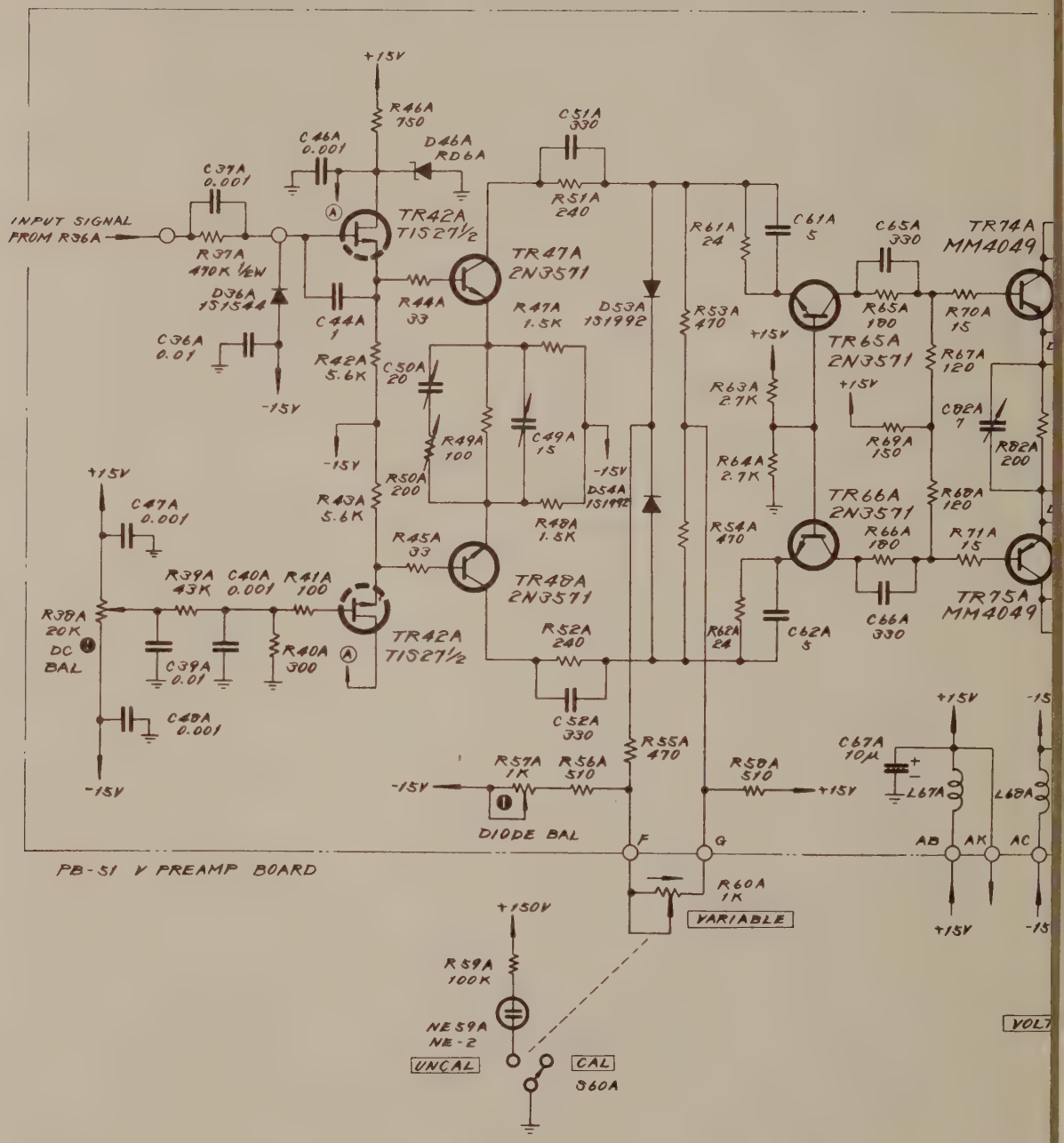




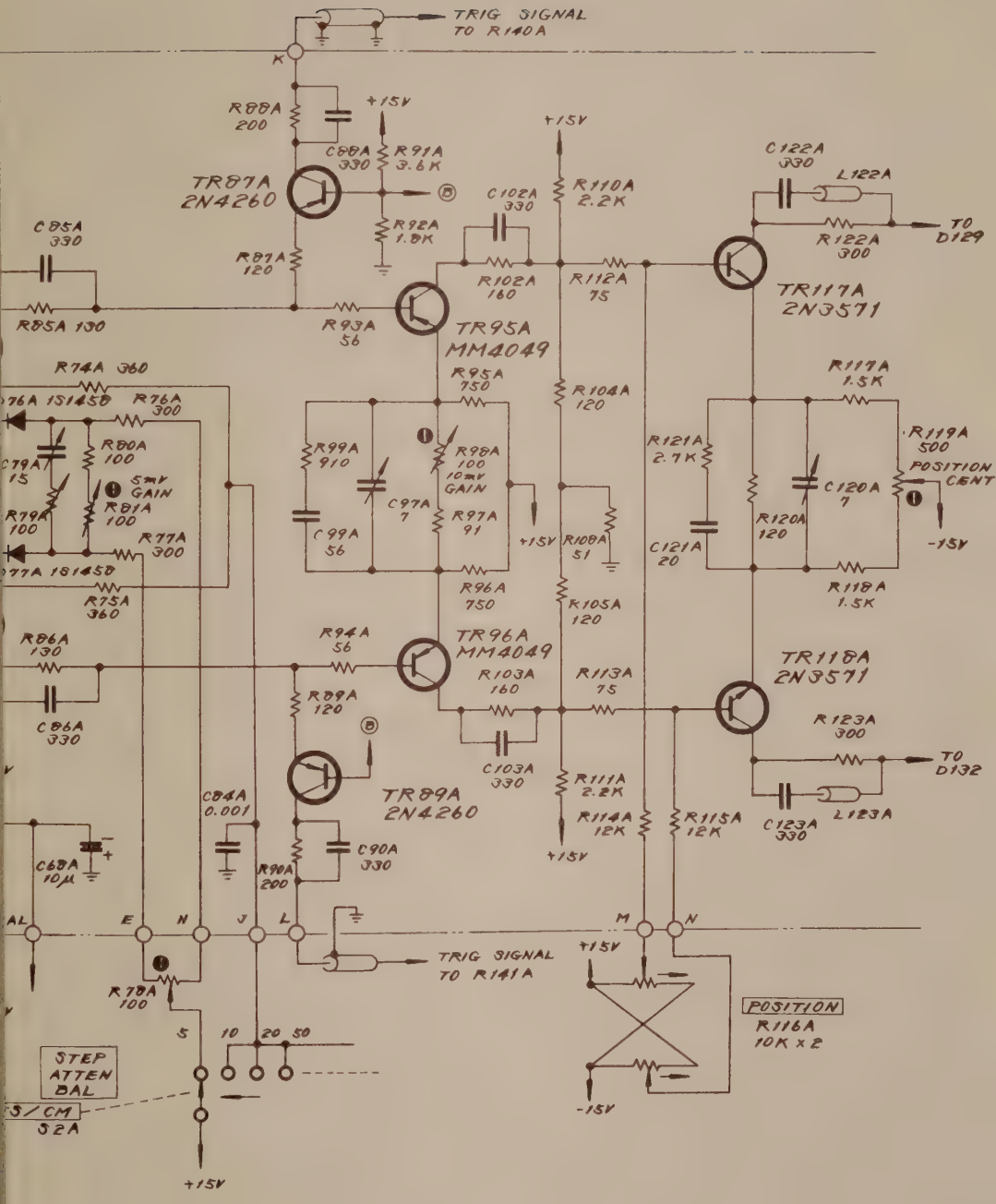
VERTICAL INPUT & ATTENUAOR

K-605226

CH 1 PREAMPLIFIER


+15V
R46A 750
C46A 0.001
D46A RD6A
C37A 0.001
INPUT SIGNAL FROM R36A
R37A 470K ½W
TR42A T1527½
C51A 330
R51A 240
TR47A 2N3571
D36A 151544
C44A 1
R44A 33
R47A 1.5K
D53A 151992
C36A 0.01
R42A 5.6K
C50A 20
-15V
R49A 100
C49A 15
R50A 200
R43A 5.6K
D54A 151992
R48A 1.5K
+15V
C47A 0.001
R45A 33
TR48A 2N3571
R39A 43K
C40A 0.001
R41A 100
R38A 20K DC BAL
TR42A T1527½
R40A 300
C39A 0.01
C48A 0.001
R52A 240
C52A 330
R55A 470
R57A 1K
R56A 510
DIODE BAL
R58A 510
F
G
R60A 1K
VARIABLE
+150V
R59A 100K
NE59A NE-2
UNCAL
CAL
360A
R61A 24
C61A 5
R53A 470
R63A 2.7K
R64A 2.7K
R54A 470
R62A 24
C62A 5
C65A 330
R65A 100
TR65A 2N3571
R66A 100
C66A 330
TR74A MM4049
R70A 15
R67A 120
C68A 7
R69A 150
R68A 120
R71A 15
TR75A MM4049
C67A 10µ
L67A
L68A
AB
AK
AC
PB-51 V PREAMP BOARD

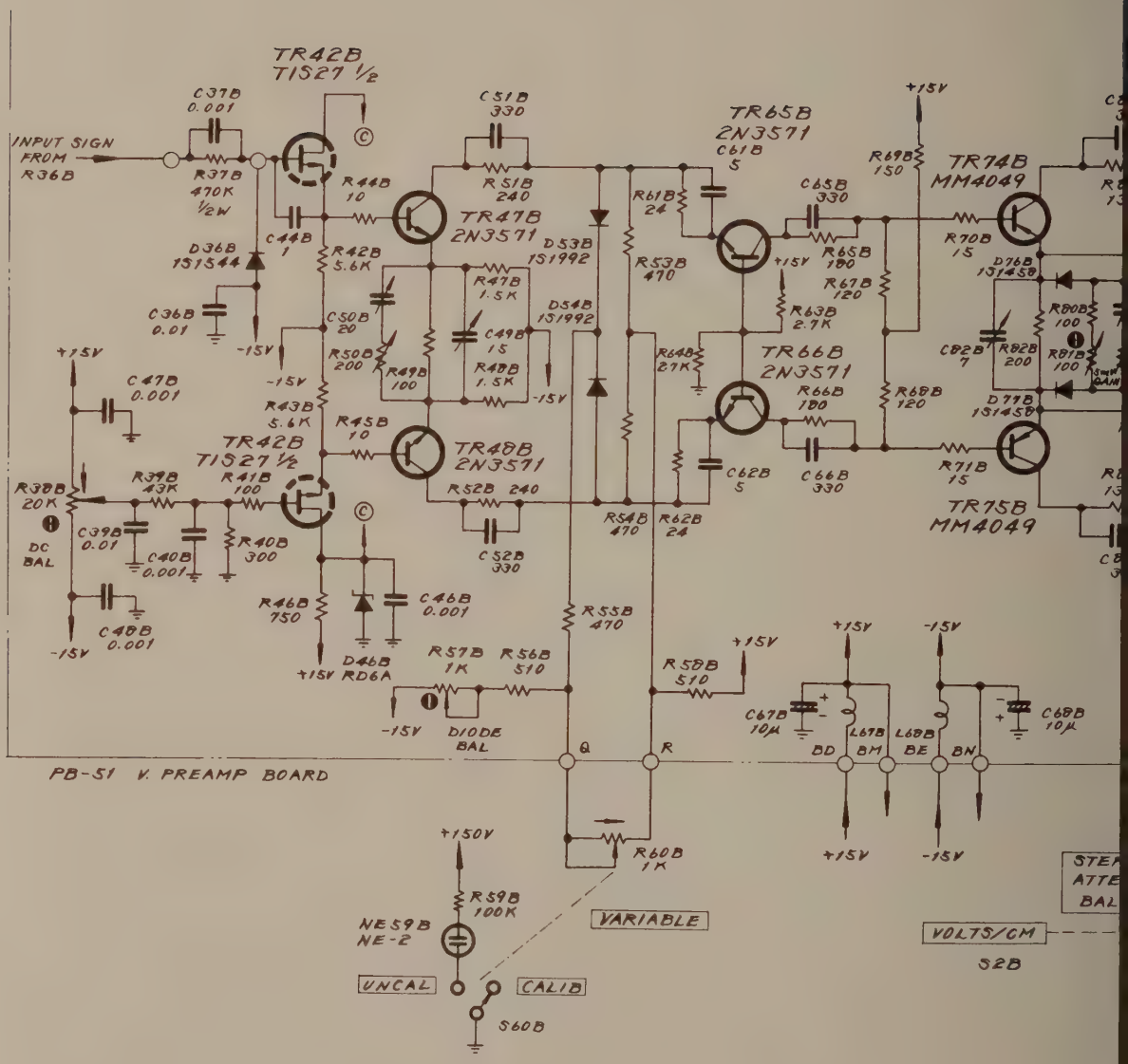
CH 2 PREAMPLIFIER ➡

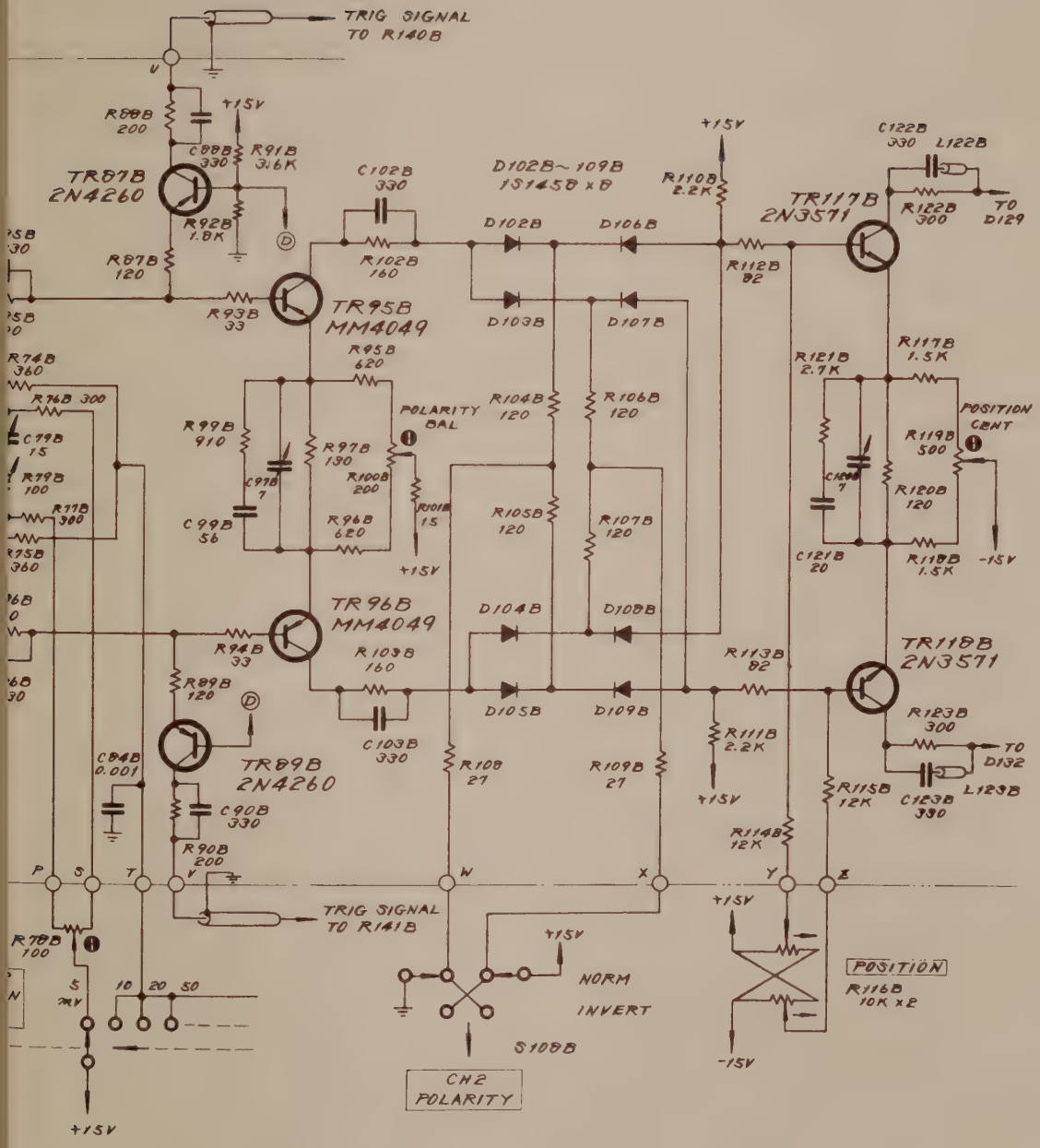


CH1 PREAMPLIFIER

K-605227

CH 2 PREAMPLIFIER

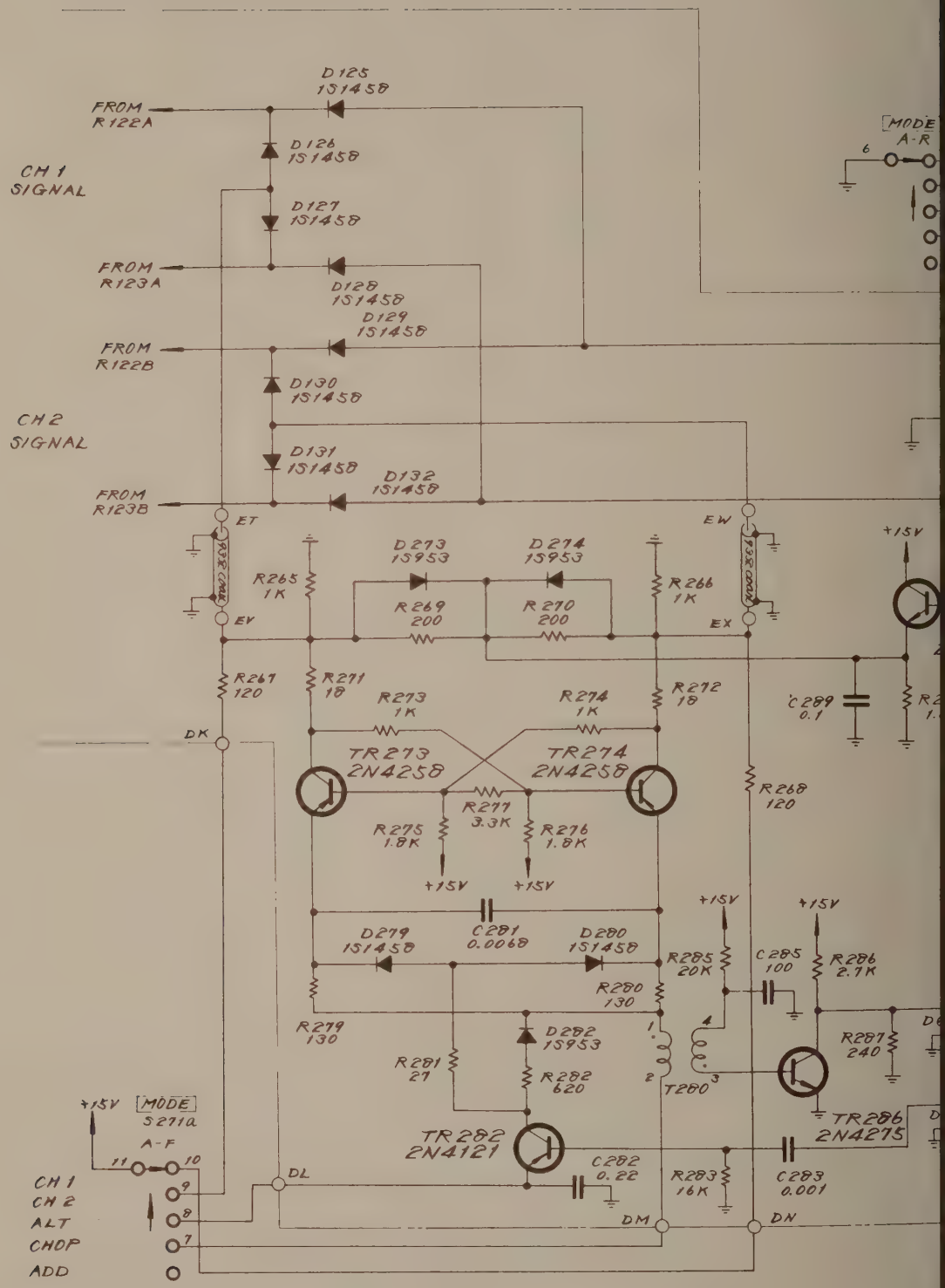

TR42B
T1527 1/2
C37B
0.001
INPUT SIGN
FROM
R36B
R37B
470K
1/2W
C44B
1
D36B
1S1544
C36B
0.01
R44B
10
R42B
5.6K
C50B
20
R50B
200
R49B
100
R43B
5.6K
-15V
+15V
C47B
0.001
R38B
20K
DC
BAL
R39B
43K
C39B
0.01
C40B
0.001
R41B
100
R40B
300
C48B
0.001
TR42B
T1527 1/2
R45B
10
TR47B
2N3571
TR48B
2N3571
C51B
330
R51B
240
R47B
1.5K
C49B
15
R48B
1.5K
D53B
1S1992
D54B
1S1992
R52B
240
C52B
330
R46B
750
D46B
RD6A
C46B
0.001
R57B
1K
R56B
510
DIODE
BAL
R55B
470
R54B
470
R62B
24
R53B
470
R61B
24
C61B
5
TR65B
2N3571
C65B
330
R65B
100
R67B
120
R63B
2.7K
R64B
27K
TR66B
2N3571
R66B
100
C66B
330
C62B
5
R68B
120
R69B
150
TR74B
MM4049
R70B
15
D76B
1S1458
C72B
7
R72B
200
R80B
100
R71B
100
D77B
1S1458
R71B
15
TR75B
MM4049
R58B
510
C67B
10μ
L67B
BM
L68B
BE
BD
BN
C68B
10μ
Q
R
R60B
1K
+150V
R59B
100K
NE59B
NE-2
VARIABLE
UNCAL
CALIB
S60B
VOLTS/CM
S2B
PB-51 V. PREAMP BOARD

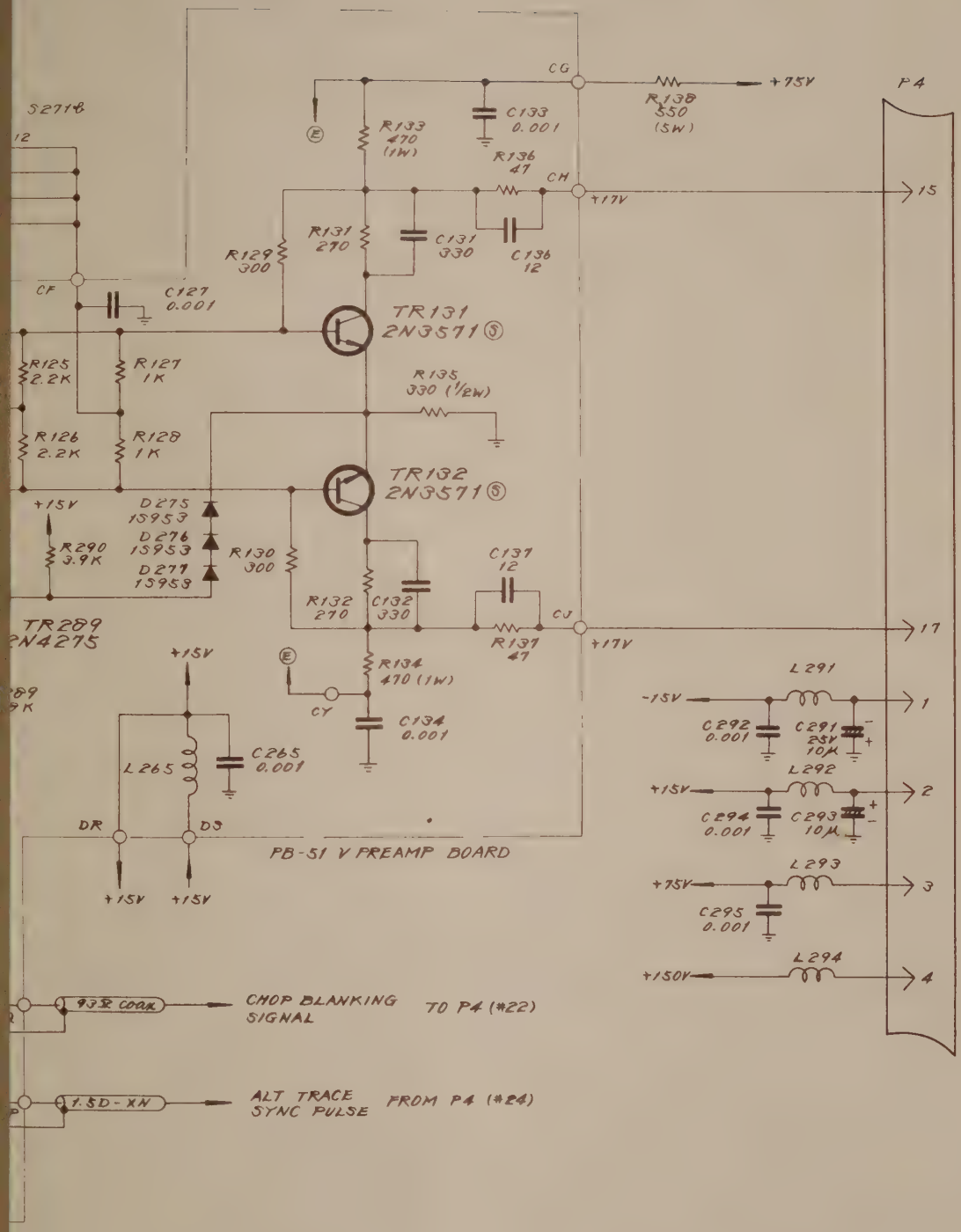


CH2 PREAMPLIFIER

K-605228

SWITCHING CIRCUIT ➡

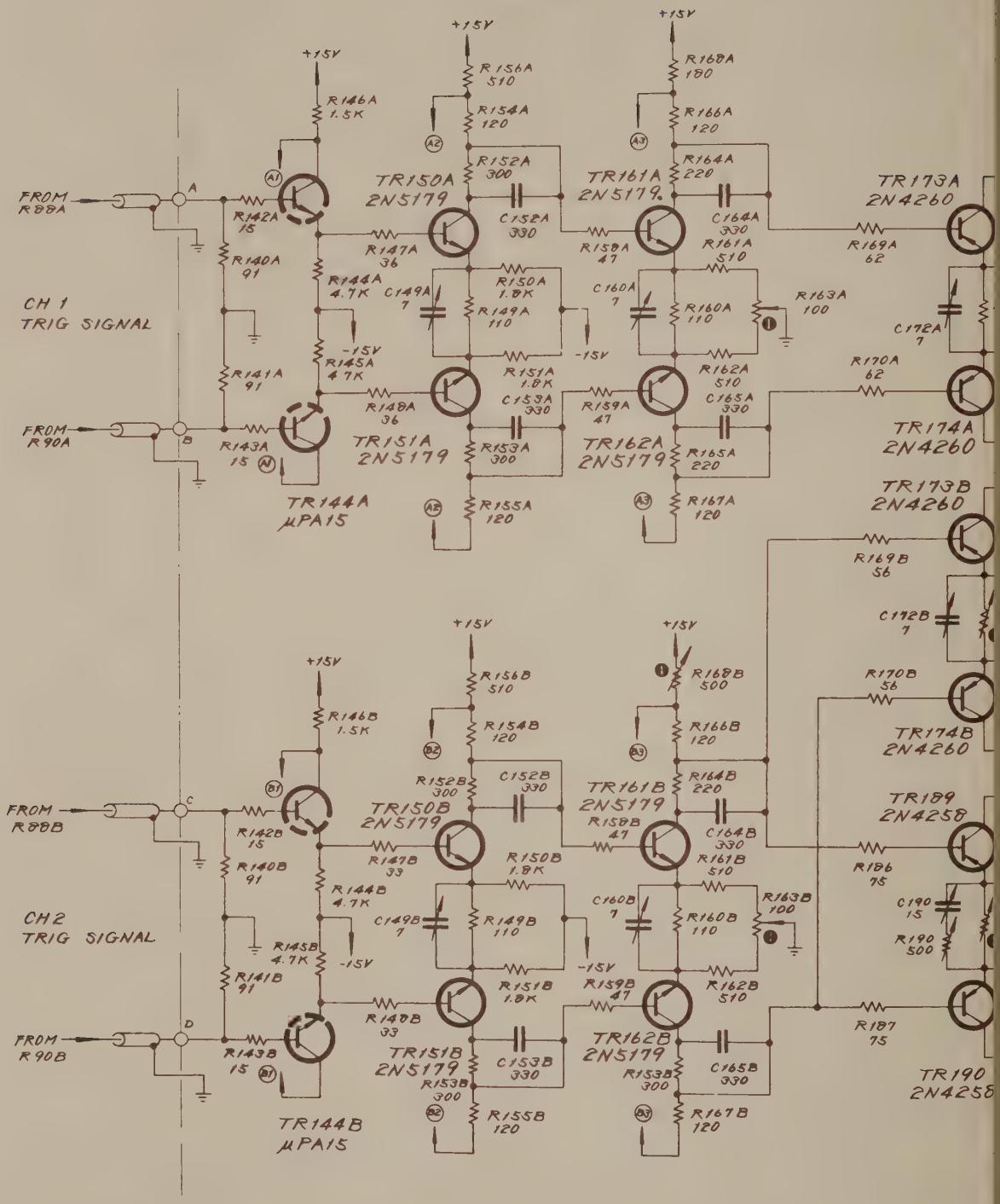

D125 1S1458
FROM R122A
D126 1S1458
CH 1 SIGNAL
D127 1S1458
FROM R123A
D128 1S1458
D129 1S1458
FROM R122B
D130 1S1458
CH 2 SIGNAL
D131 1S1458
D132 1S1458
FROM R123B
MODE A-R
ET
EV
EW
EX
R265 1K
D273 1S953
D274 1S953
R266 1K
R269 200
R270 200
+15V
R267 120
R271 18
R273 1K
R274 1K
R272 18
C289 0.1
DK
TR273 2N4258
TR274 2N4258
R268 120
R277 3.3K
R275 1.8K
R276 1.8K
+15V
+15V
C281 0.006B
D279 1S1458
D280 1S1458
R285 20K
C285 100
R286 2.7K
R280 130
R279 130
D282 1S953
R281 27
R282 620
T280
R287 240
TR286 2N4275
TR282 2N4121
C282 0.22
R283 16K
C283 0.001
MODE S211a A-F
CH 1
CH 2
ALT
CHOP
ADD
DL
DM
DN



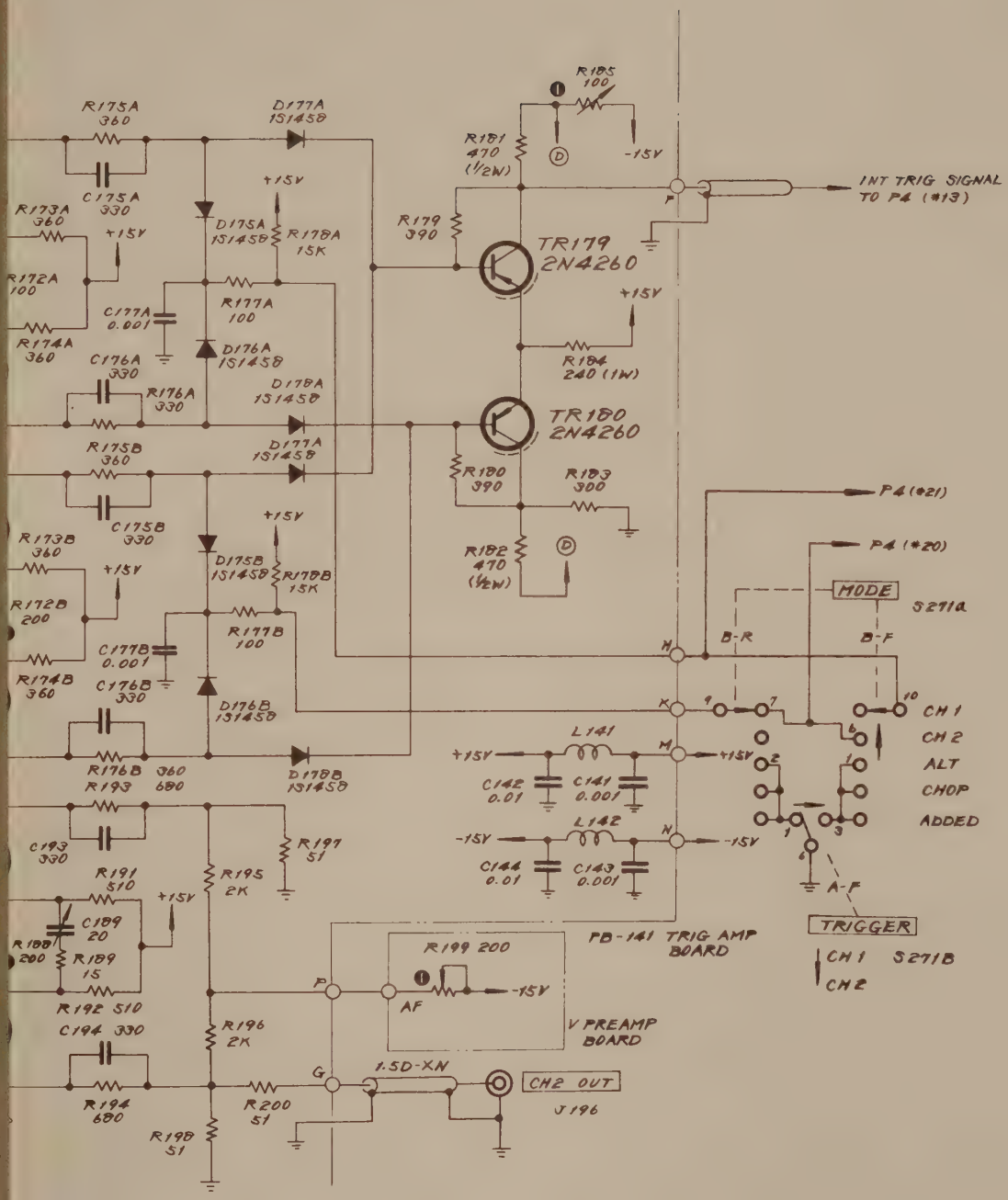
SWITCHING CIRCUIT

K-605229

TRIGGER AMPLIFIER ➡


CH 1
TRIG SIGNAL
CH 2
TRIG SIGNAL
FROM R88A
FROM R90A
FROM R88B
FROM R90B
+15V
-15V
TR144A μPA15
TR144B μPA15
TR150A 2N5179
TR151A 2N5179
TR161A 2N5179
TR162A 2N5179
TR150B 2N5179
TR151B 2N5179
TR161B 2N5179
TR162B 2N5179
TR173A 2N4260
TR174A 2N4260
TR173B 2N4260
TR174B 2N4260
TR189 2N4258
TR190 2N4258
R146A 1.5K
R142A 15
R140A 91
R141A 91
R143A 15
R144A 4.7K
R145A 4.7K
R147A 36
R148A 36
R156A 510
R154A 120
R152A 300
R150A 1.8K
R149A 110
R151A 1.8K
R153A 300
R155A 120
C149A 7
C152A 330
C153A 330
R168A 180
R166A 120
R164A 220
R158A 47
R159A 47
R161A 510
R160A 110
R162A 510
R165A 220
R167A 120
C160A 7
C164A 330
C165A 330
R163A 100
R169A 62
C172A 7
R170A 62
R146B 1.5K
R142B 15
R140B 91
R141B 91
R143B 15
R144B 4.7K
R145B 4.7K
R147B 33
R148B 33
R156B 510
R154B 120
R152B 300
R150B 1.8K
R149B 110
R151B 1.8K
R153B 300
R155B 120
C149B 7
C152B 330
C153B 330
R168B 500
R166B 120
R164B 220
R158B 47
R159B 47
R161B 510
R160B 110
R162B 510
R153B 300
R167B 120
C160B 7
C164B 330
C165B 330
R163B 100
R169B 56
C172B 7
R170B 56
R186 75
C190 15
R190 500
R187 75

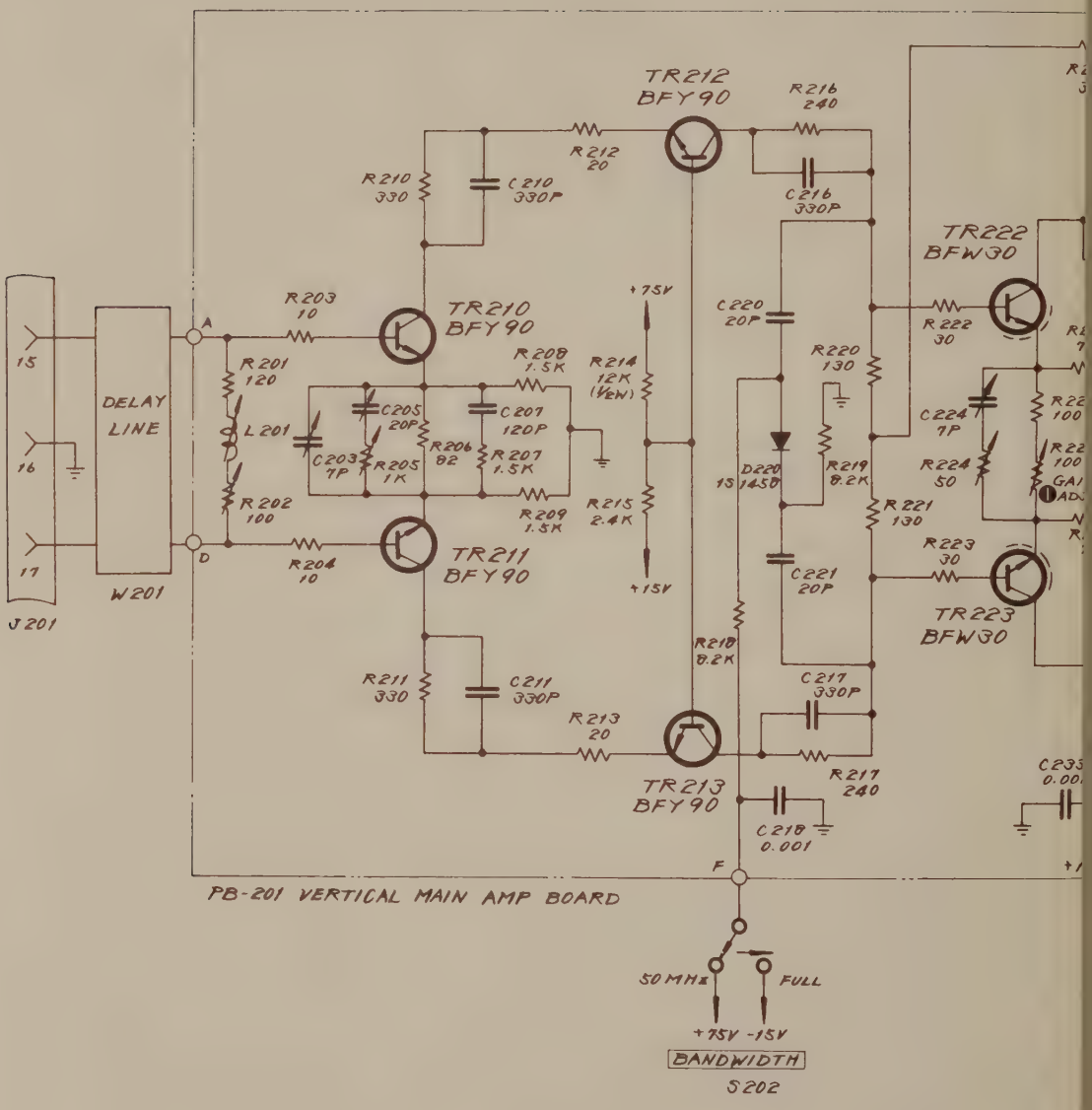
VERT MAIN AMPLIFIER ➡



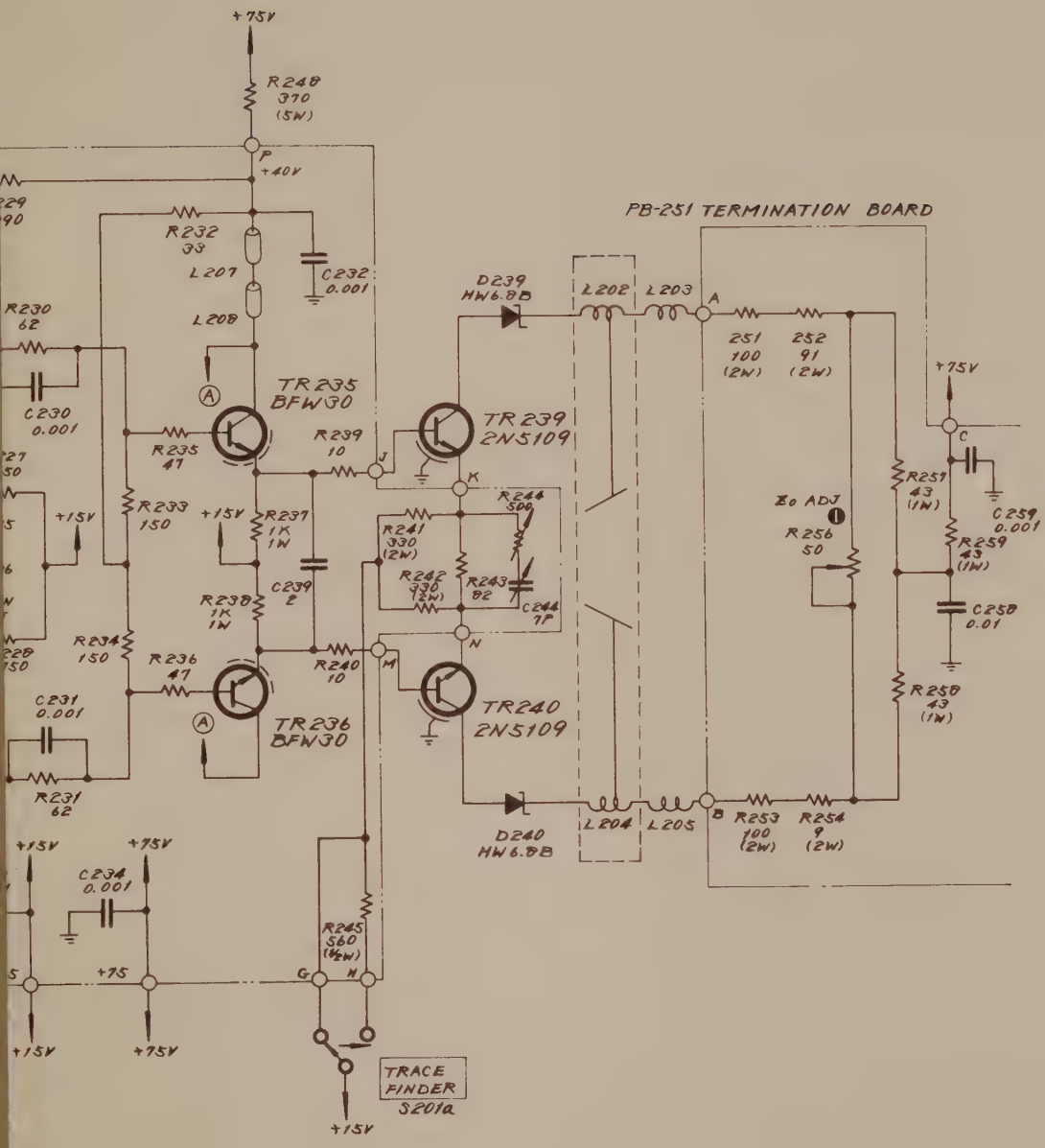
TRIGGER AMPLIFIER

K-605230

VERT MAIN AMPLIFIER ➡

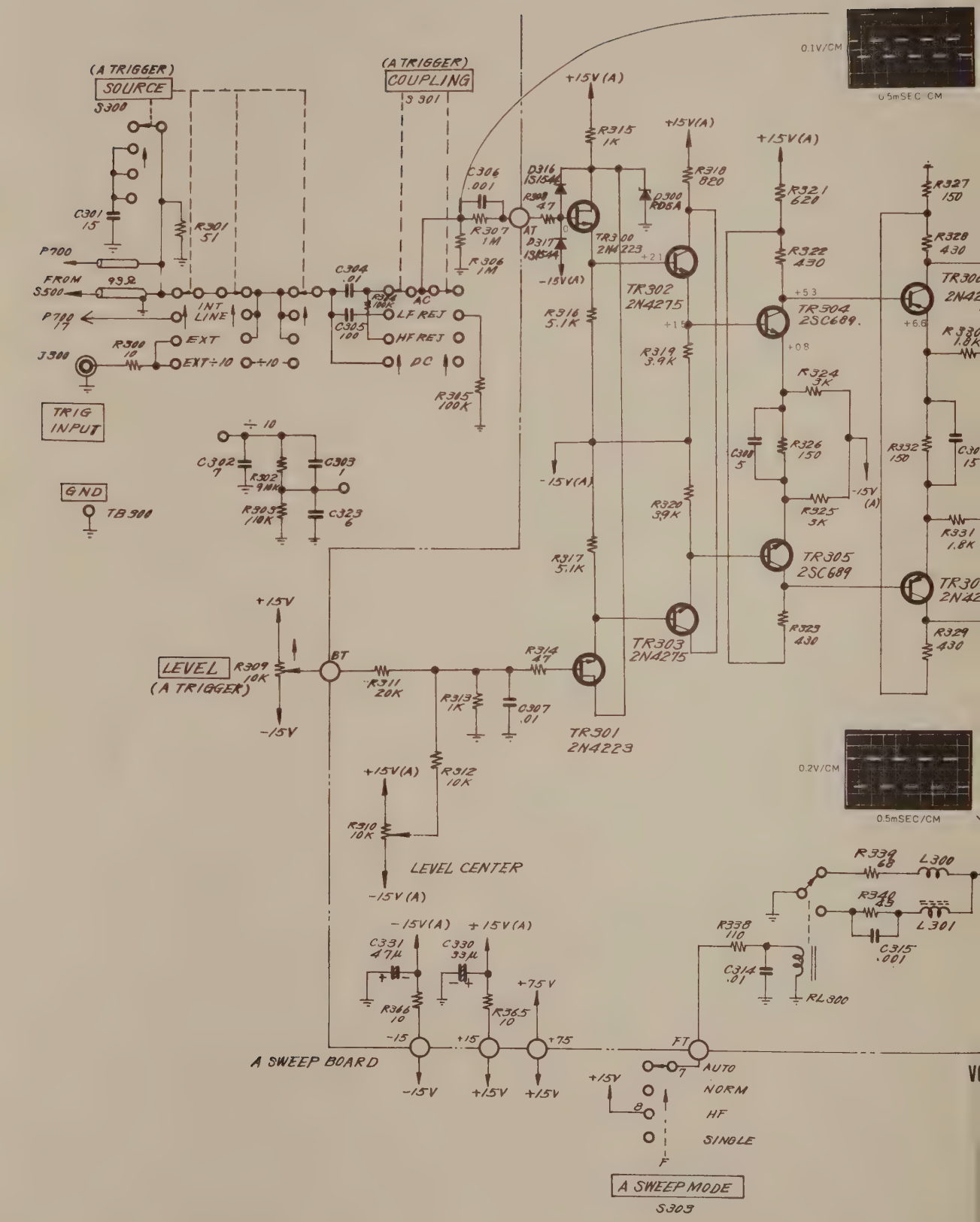

TR212
BFY90
R216
240
R212
20
R210
330
C210
330P
C216
330P
TR222
BFW30
R203
10
TR210
BFY90
+75V
C220
20P
R222
30
R208
1.5K
R214
12K
(VAR)
R220
130
15
DELAY
LINE
A
R201
120
C205
20P
C207
120P
C224
7P
16
L201
C203
7P
R206
82
R205
1K
R207
1.5K
D220
1S1450
R219
8.2K
R224
50
R202
100
R209
1.5K
R215
2.4K
R221
130
17
D
R204
10
TR211
BFY90
-15V
C221
20P
R223
30
TR223
BFW30
J201
W201
R218
8.2K
R211
330
C211
330P
C217
330P
R213
20
R217
240
TR213
BFY90
C218
0.001
F
PB-201 VERTICAL MAIN AMP BOARD
50MHz
FULL
+75V -15V
BANDWIDTH
S202

A TRIGGER GENERATOR ➡

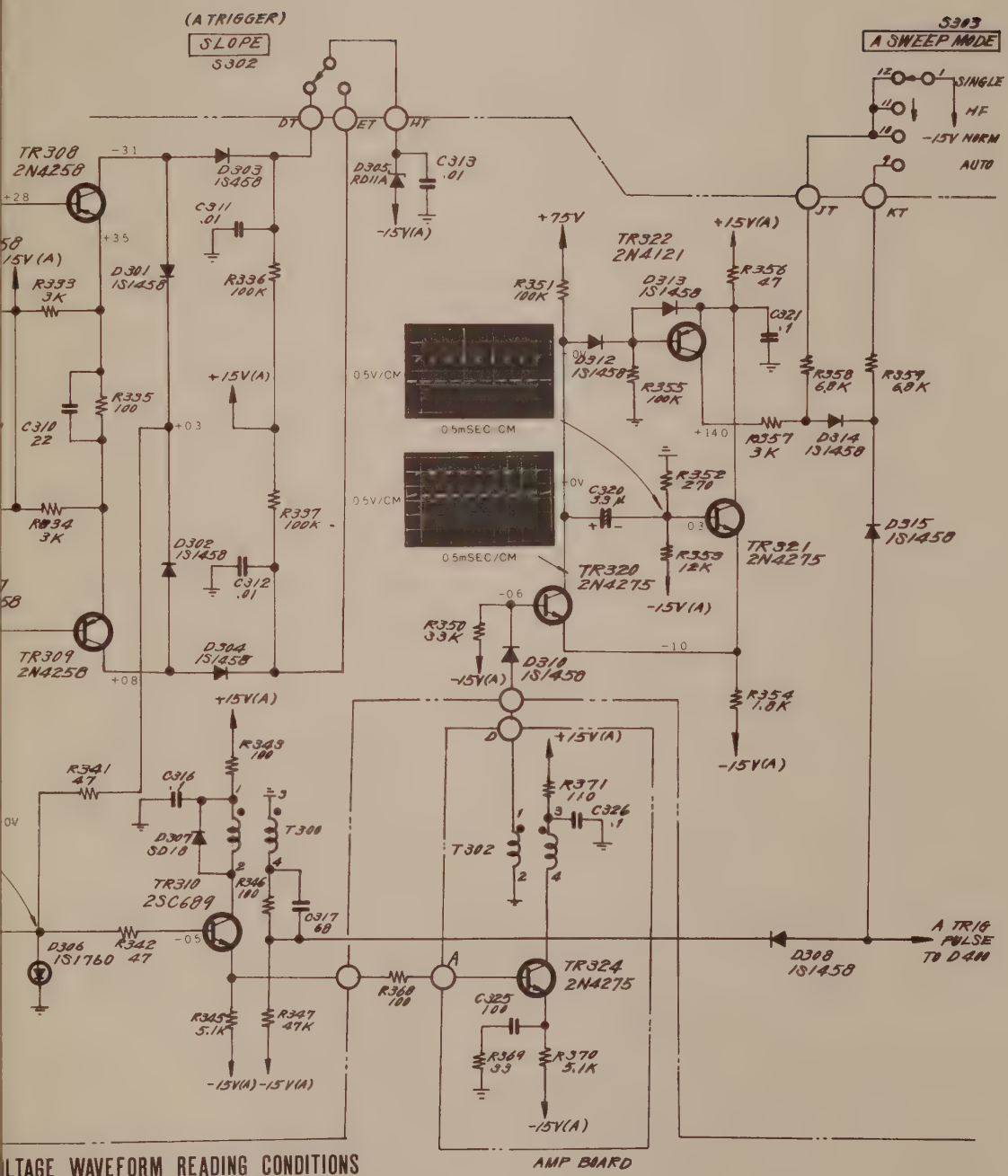


VERT. MAIN AMPLIFIER

K-605231


(A TRIGGER)
SOURCE
S300
(A TRIGGER)
COUPLING
S 301
+15V(A)
R315 1K
+15V(A)
+15V(A)
R318 820
R321 620
R327 150
C306 .001
D316 1S1544
R309 47
D317 1S1544
D300 RD5A
R307 1M
R306 1M
TR300 2N4223
R322 430
R328 430
C301 15
R301 51
P700
FROM S500
993Ω
INT LINE
P700
J300
R300 10
EXT
EXT÷10
+10
C304 .01
R304 100K
AC
C305 100
LF REJ
HF REJ
DC
R305 100K
-15V(A)
R316 5.1K
TR302 2N4275
TR304 2SC689
TR306 2N42
R319 3.9K
R324 3K
R326 150
R325 3K
R332 150
C308 5
-15V (A)
TRIG INPUT
÷ 10
C302 7
R302 9.1K
C303 1
R303 10K
C323 6
GND
TB300
-15V(A)
R320 39K
R317 5.1K
TR305 2SC689
TR303 2N4275
TR306 2N42
R323 430
R329 430
R331 1.8K
+15V
LEVEL
R309 10K
(A TRIGGER)
-15V
BT
R311 20K
R314 47
R313 1K
C307 .01
TR301 2N4223
0.1V/CM
0.5mSEC/CM
0.2V/CM
0.5mSEC/CM
+15V(A)
R312 10K
R310 10K
LEVEL CENTER
-15V(A)
R339 68
L300
R340 45
L301
C315 .001
-15V(A)
+15V(A)
C331 47μ
C330 33μ
R338 110
C314 .01
RL300
+75V
R366 10
R365 10
-15
+15
+75
FT
A SWEEP BOARD
-15V
+15V
+15V
+15V
AUTO
NORM
HF
SINGLE
A SWEEP MODE
S303

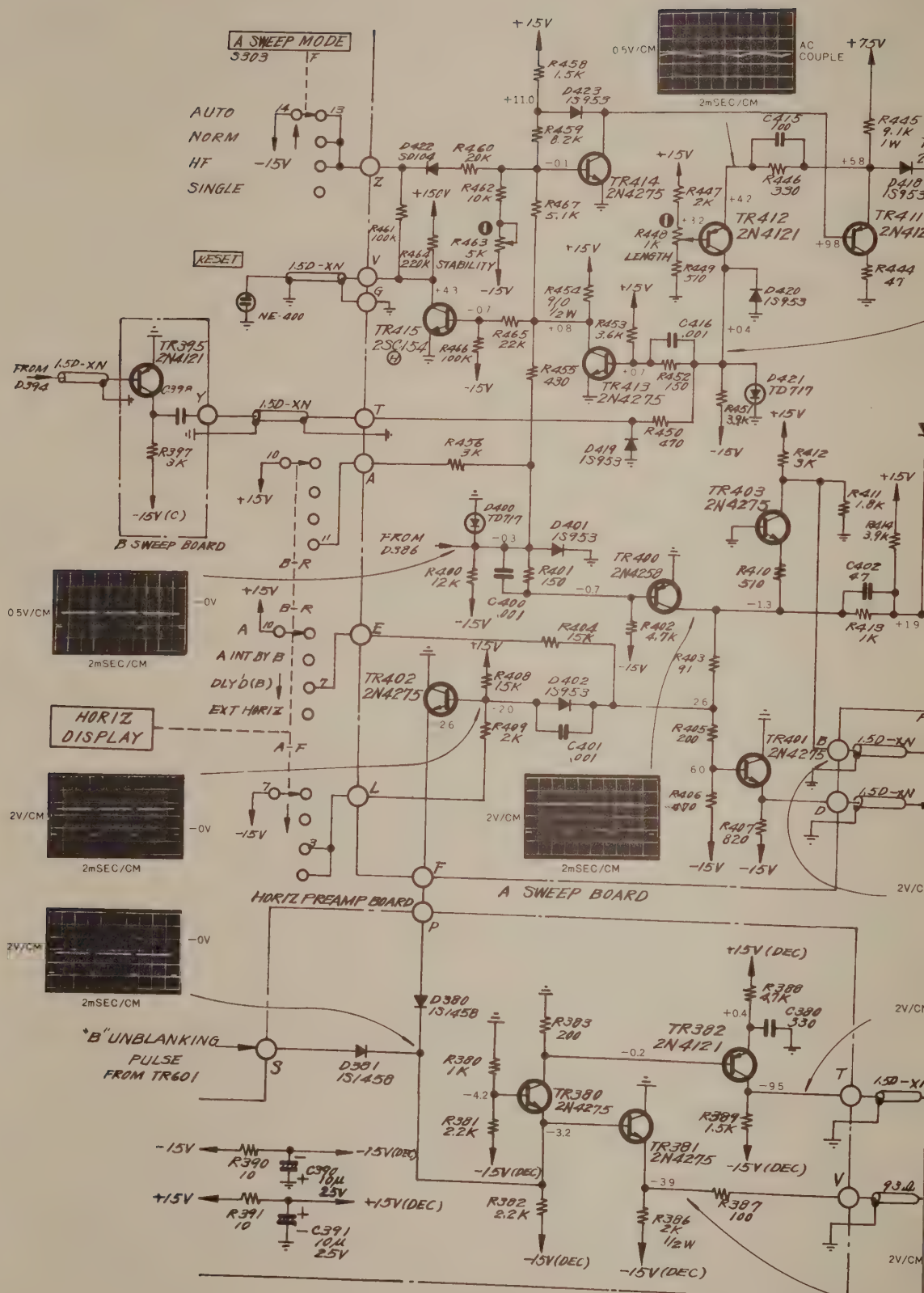
A SWEEP GENERATOR ➡



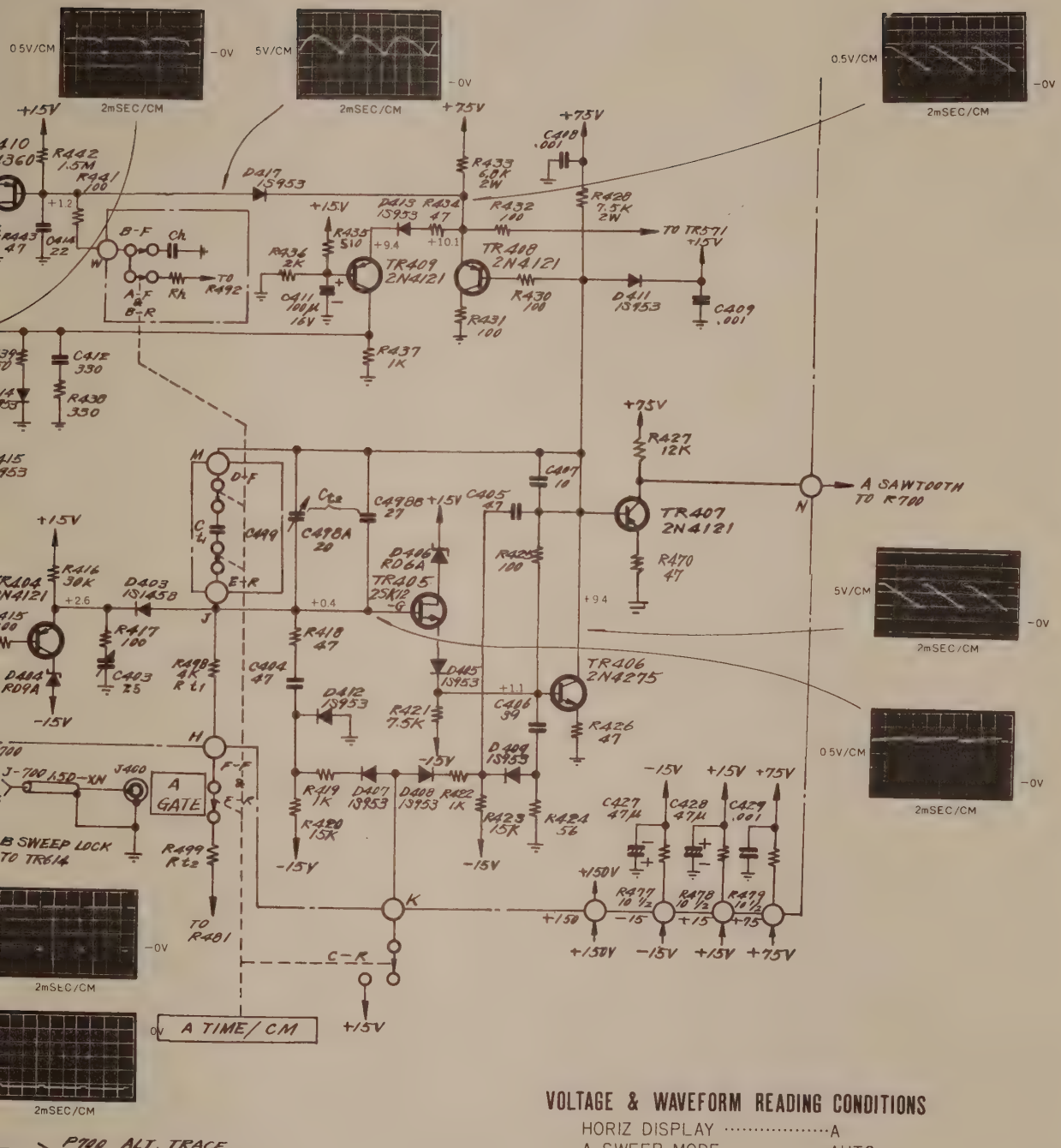
LTAGE WAVEFORM READING CONDITIONS

INPUT SIGNAL ..... CAL OUT
HORIZ DISPLAY ..... A
A SWEEP MODE ..... AUTO
SOURCE ..... INT
COUPLING ..... AC
SLOPE ..... +
LEVEL ..... MIDRANGE

A TRIGGER GENERATOR


A SWEEP MODE
S303
AUTO
NORM
HF
SINGLE
-15V
+15V
R458 1.5K
D423 1S953
R459 8.2K
D422 SD104
R460 20K
R462 10K
R461 100K
R463 5K STABILITY
R467 5.1K
TR414 2N4275
R447 2K
TR412 2N4121
R448 1K LENGTH
R449 510
D420 1S953
C415 100
R446 330
R445 9.1K 1W
D418 1S953
TR411 2N412
R444 47
+7.5V
AC COUPLE
0.5V/CM
2mSEC/CM
RESET
1.5D-XN
NE-400
R464 220K
TR415 2SC154
R465 22K
R466 100K
R454 910 1/2W
R453 3.6K
C416 .001
R455 430
TR413 2N4275
R452 130
D421 TD717
R451 3.9K
R450 470
D419 1S953
TR395 2N4121
FROM D394
C399A
R397 3K
-15V(C)
B SWEEP BOARD
R456 3K
R412 3K
TR403 2N4275
R411 1.8K
R414 3.9K
D400 TD717
D401 1S953
FROM D386
R400 12K
R401 150
C400 .001
TR400 2N4250
R410 510
C402 47
R419 1K
B-R
A INT BY B
DLY'D(B)
EXT HORIZ
HORIZ DISPLAY
A-F
R404 15K
R402 4.7K
R403 91
TR402 2N4275
R408 15K
D402 1S953
R409 2K
C401 .001
R405 200
R406 470
R407 820
TR401 2N4275
1.5D-XN
HORIZ PREAMP BOARD
A SWEEP BOARD
2V/CM
"B" UNBLANKING PULSE FROM TR601
D380 1S1458
D381 1S1458
R383 200
R380 1K
R381 2.2K
TR380 2N4275
TR381 2N4275
TR382 2N4121
R388 4.7K
C380 330
R389 1.5K
R387 100
R386 2K 1/2W
R390 10
C390 10μ 25V
R391 10
C391 10μ 25V
R382 2.2K
+15V(DEC)
-15V(DEC)
93Ω

B TRIGGER GENERATOR ➡



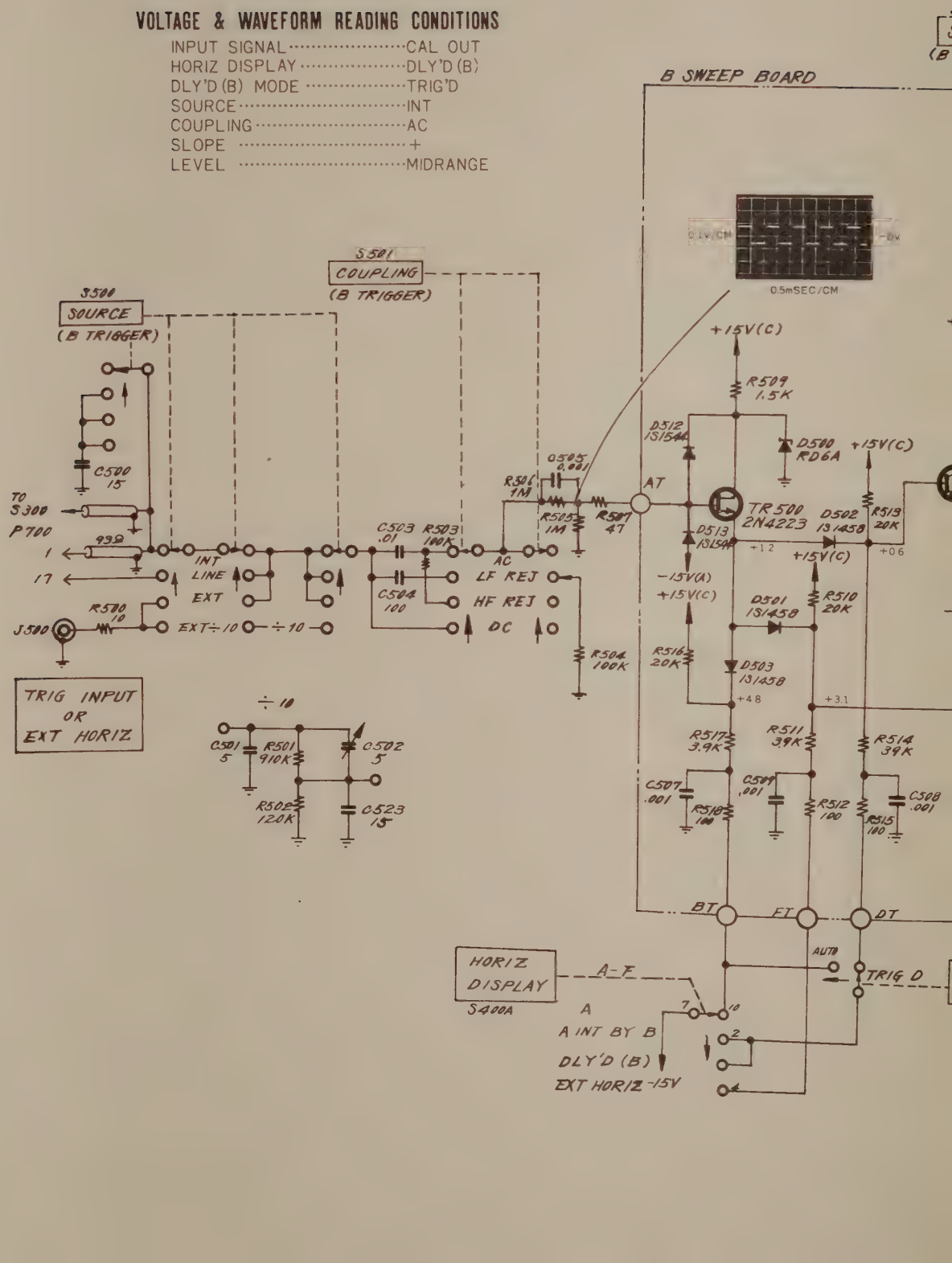
VOLTAGE & WAVEFORM READING CONDITIONS

HORIZ DISPLAY ..... A
A SWEEP MODE ..... AUTO
A TIME/CM ..... 0.5 mSEC

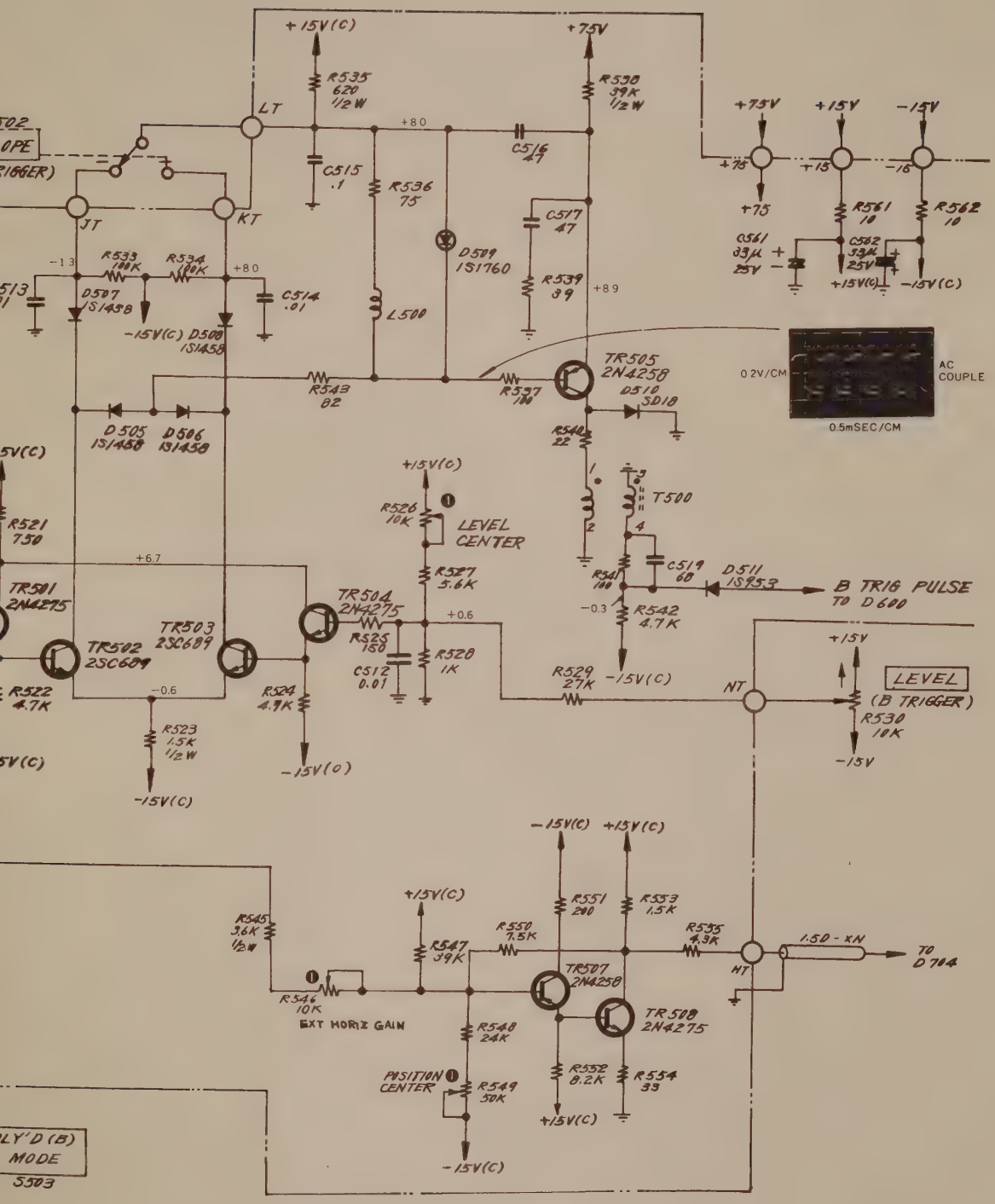
A SWEEP GENERATOR

VOLTAGE & WAVEFORM READING CONDITIONS

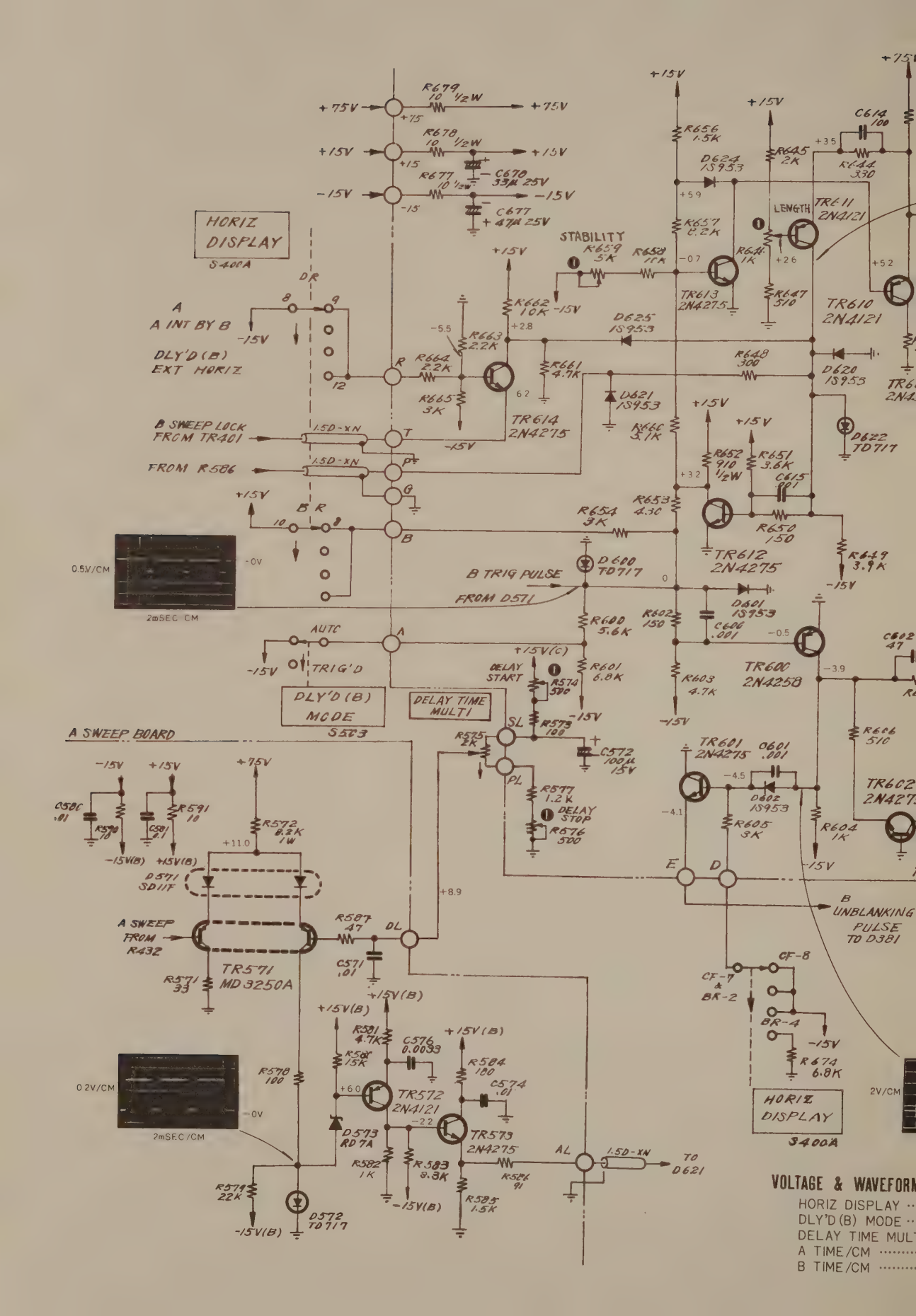
INPUT SIGNAL	CAL OUT
HORIZ DISPLAY	DLY'D (B)
DLY'D (B) MODE	TRIG'D
SOURCE	INT
COUPLING	AC
SLOPE	+
LEVEL	MIDRANGE



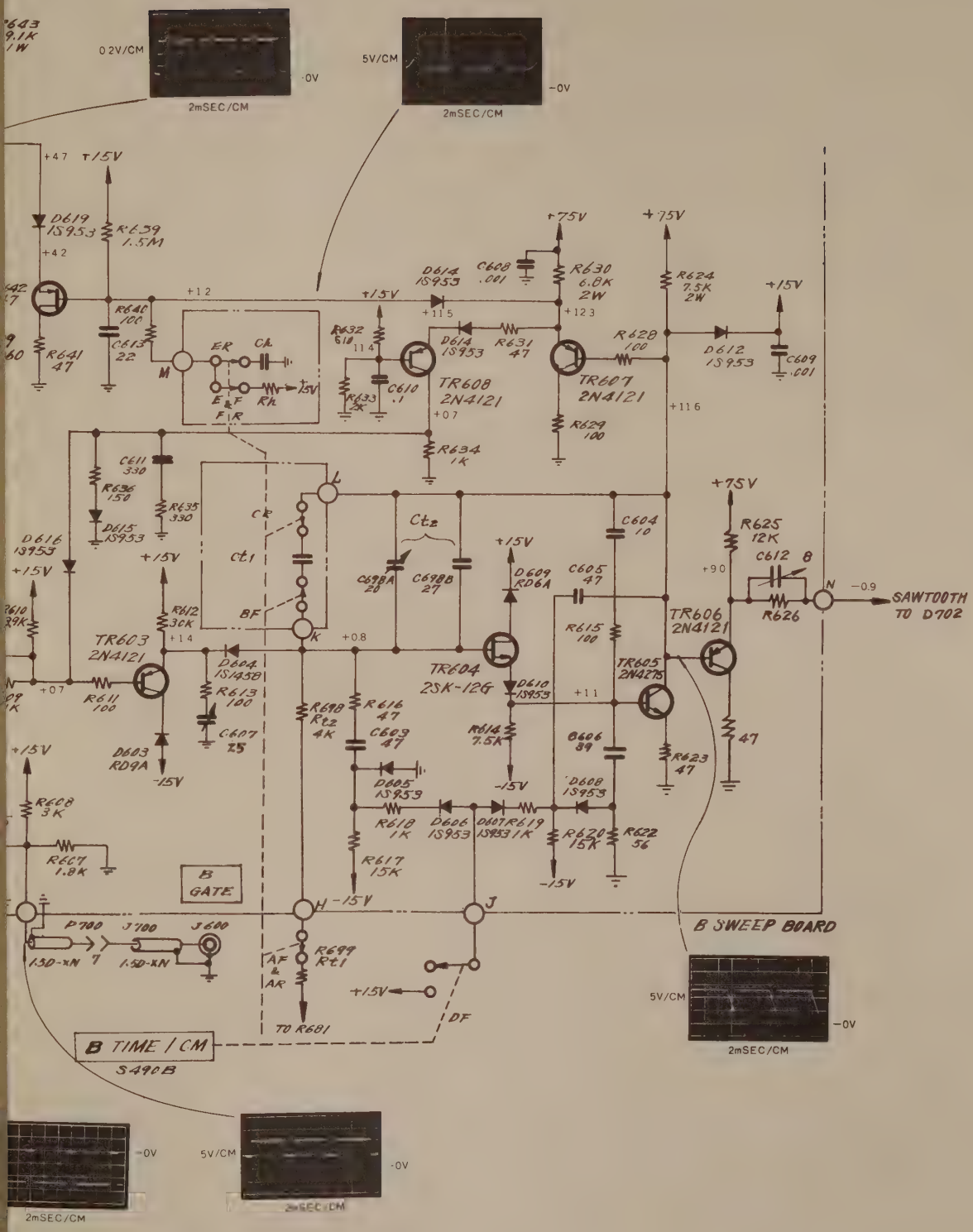
B SWEEP GENERATOR ➡



B TRIGGER GENERATOR


HORIZ DISPLAY
S400A
DLY'D (B) MODE
S503
DELAY TIME MULTI
A SWEEP BOARD
HORIZ DISPLAY
3400A
STABILITY
LENGTH
A INT BY B
DLY'D (B) EXT HORIZ
B SWEEP LOCK FROM TR401
FROM R586
B TRIG PULSE FROM D571
TRIG'D
DELAY START
DELAY STOP
A SWEEP FROM R432
B UNBLANKING PULSE TO D381
TO D621
TR571 MD3250A
TR572 2N4121
TR573 2N4275
TR600 2N4258
TR601 2N4275
TR602 2N4275
TR610 2N4121
TR611 2N4121
TR612 2N4275
TR613 2N4275
TR614 2N4275
0.5V/CM
2mSEC CM
0.2V/CM
2mSEC/CM
2V/CM
VOLTAGE & WAVEFORM
HORIZ DISPLAY
DLY'D (B) MODE
DELAY TIME MULT
A TIME/CM
B TIME/CM

TIMING SWITCH "A" ➡

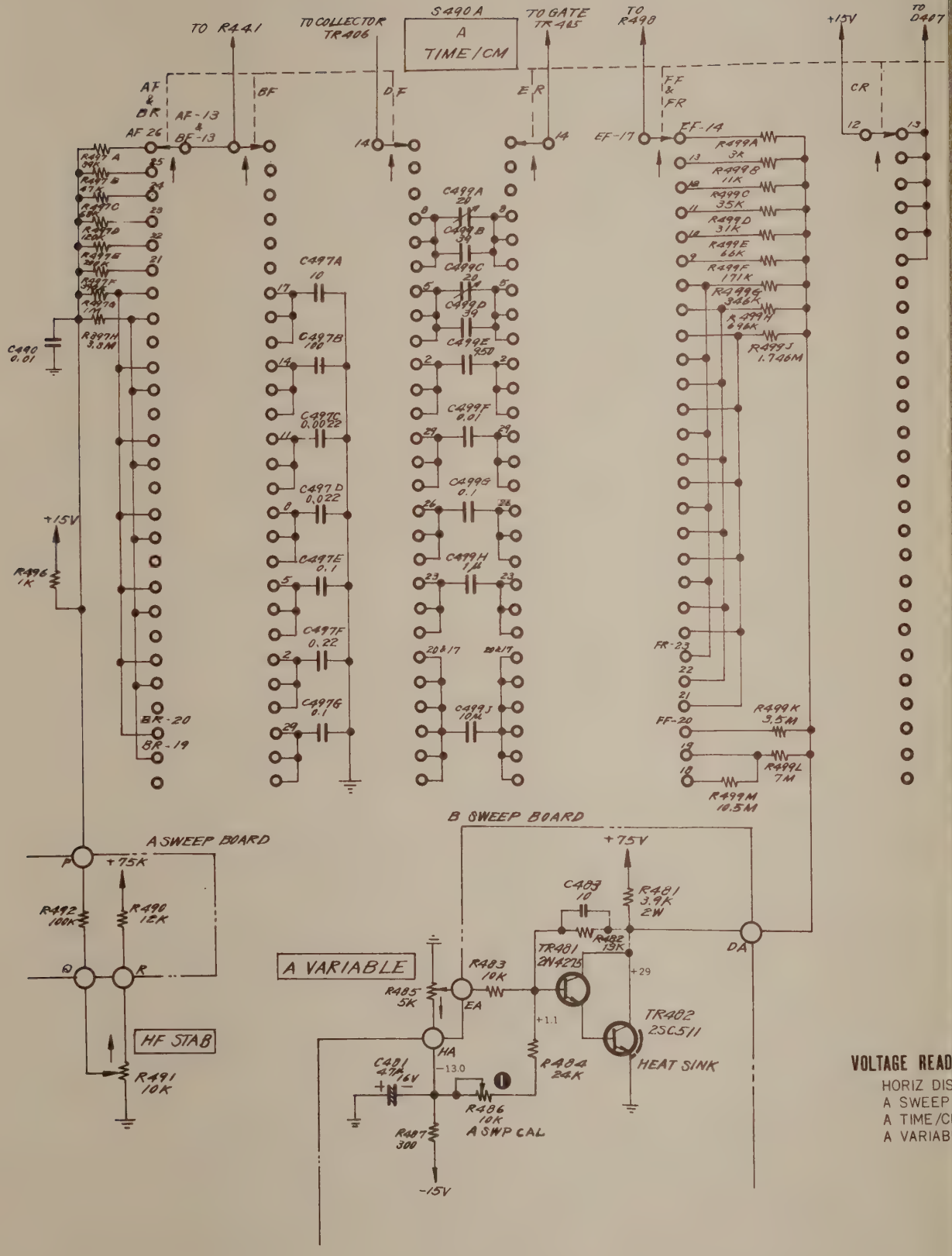


READING CONDITIONS

- ·····DLY'D (B)
- ·····TRIG'D
- T ·····5.00
- ·····0.5 mSEC
- ·····0.1 mSEC

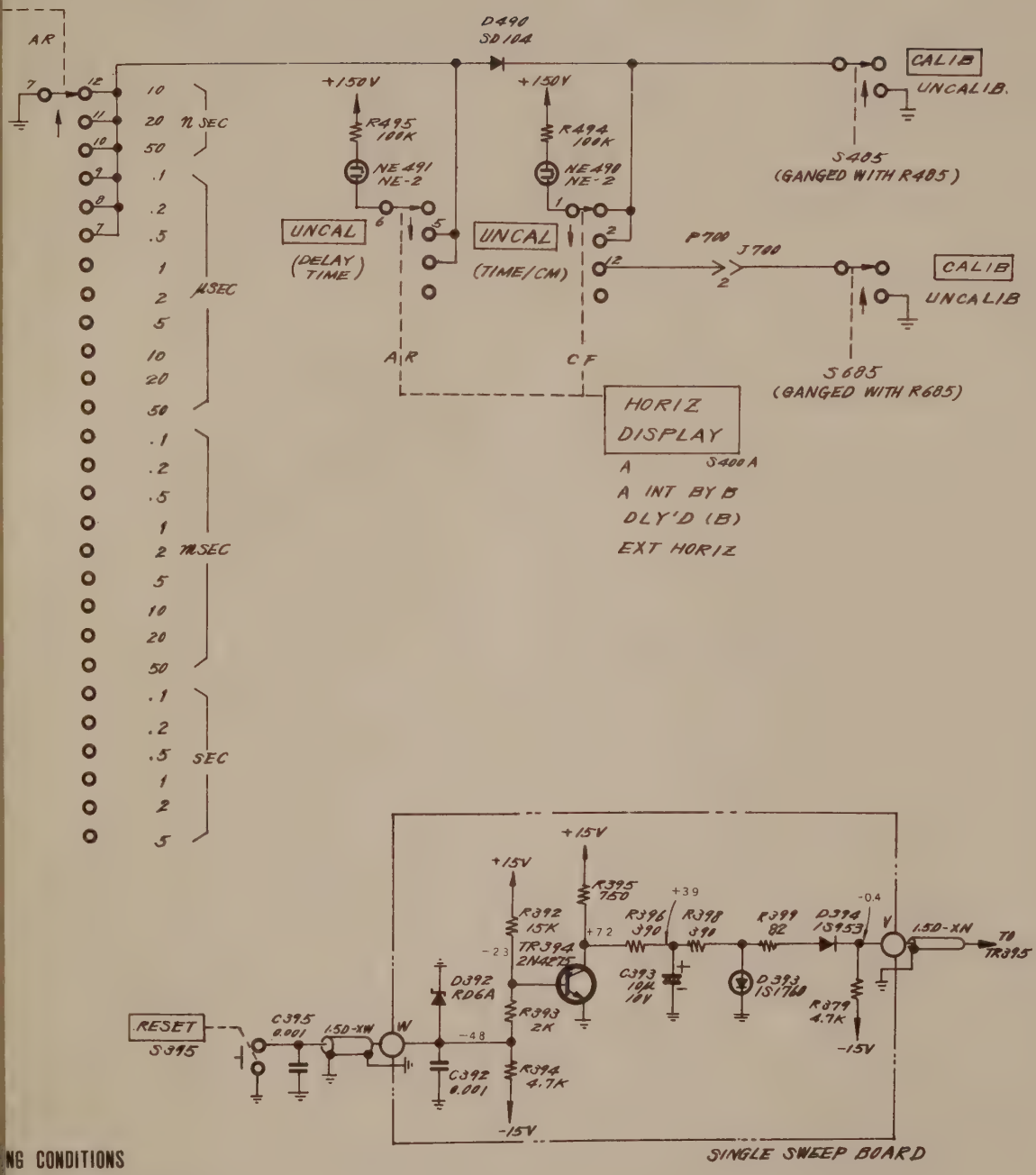
B SWEEP GENERATOR

K—605086—2



VOLTAGE READI
HORIZ DIS
A SWEEP
A TIME/CM
A VARIABL

TIMING SWITCH "B" ➡



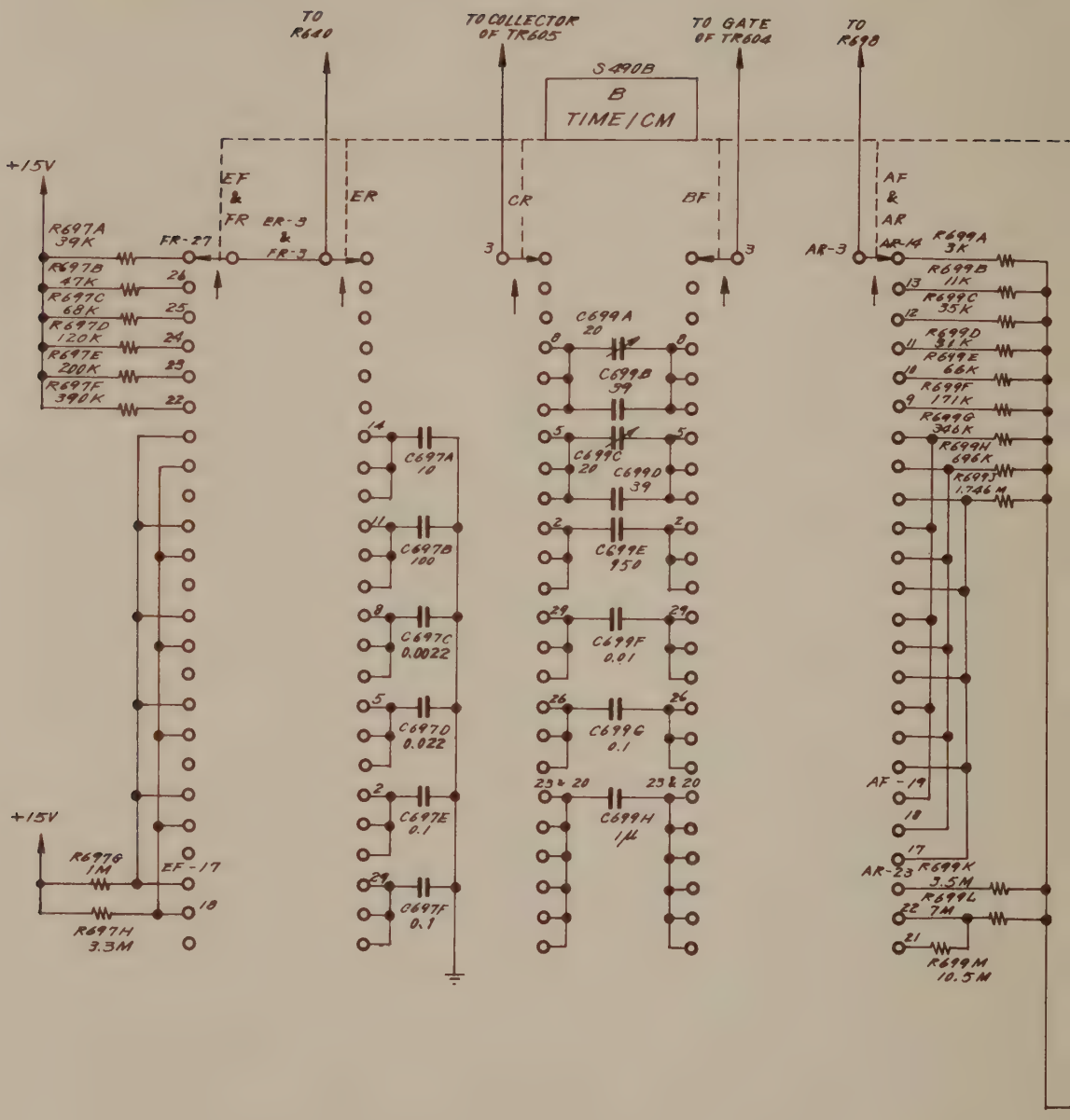
SINGLE SWEEP BOARD

NG CONDITIONS

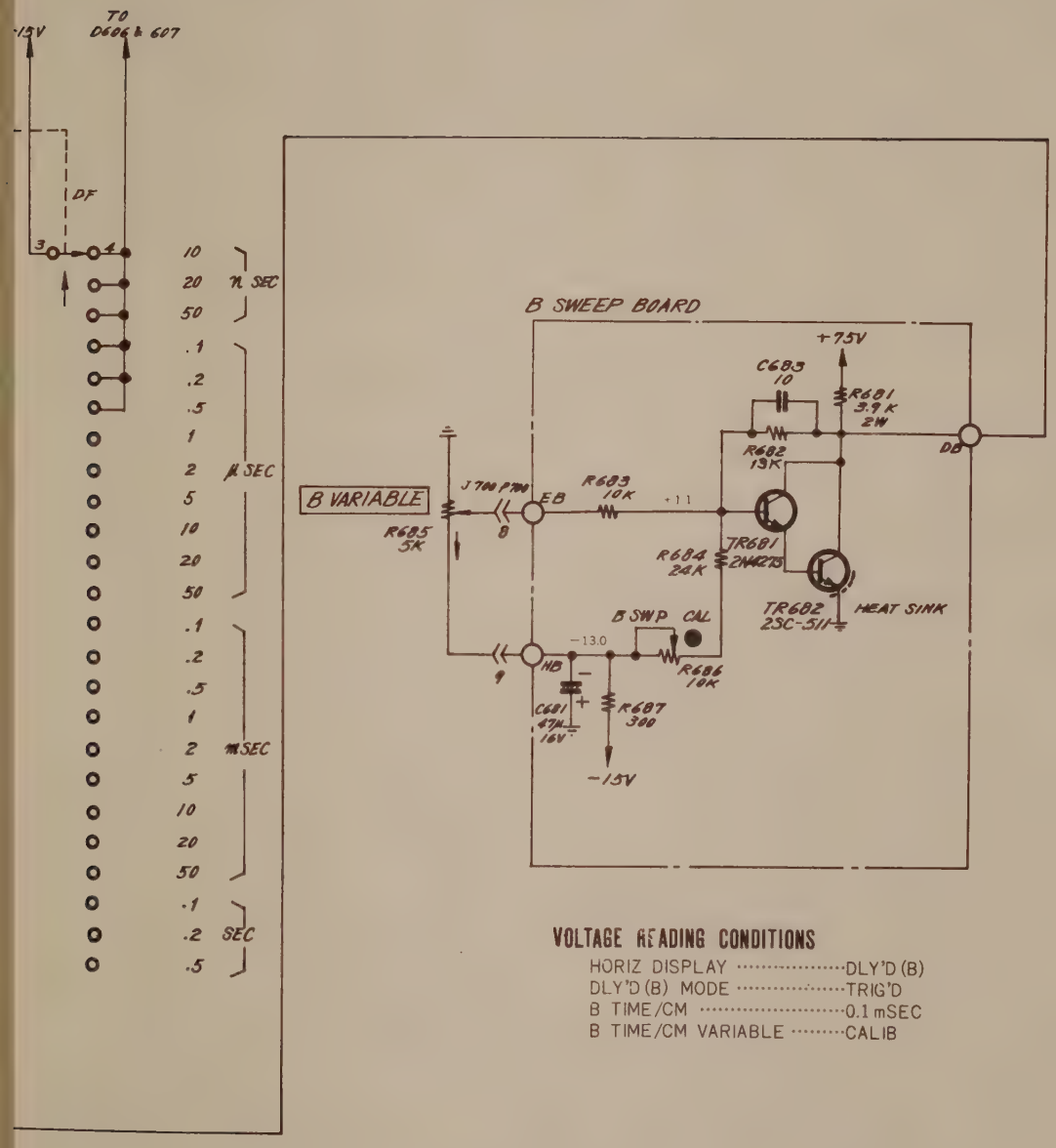
PLAY ..... A
MODE ..... AUTO
1 ..... 0.5 mSEC
LE ..... CALIB

TIMING SWITCH "A"

K-605087-2


TO R640
TO COLLECTOR OF TR605
TO GATE OF TR604
TO R698
S490B
B
TIME/CM
+15V
EF & FR
ER-3 & FR-3
ER
CR
BF
AF & AR
AR-3
AR-14
R697A 39K
FR-27
R697B 47K
R697C 68K
R697D 120K
R697E 200K
R697F 390K
C697A 10
C697B 100
C697C 0.0022
C697D 0.022
C697E 0.1
C697F 0.1
C699A 20
C699B 39
C699C 20
C699D 39
C699E 950
C699F 0.01
C699G 0.1
23 & 20
C699H 1μ
R699A 3K
R699B 11K
R699C 35K
R699D 81K
R699E 66K
R699F 171K
R699G 346K
R699H 696K
R699J 1.746M
AF-19
AR-23
R699K 3.5M
R699L 7M
R699M 10.5M
+15V
R697G 1M
EF-17
R697H 3.3M

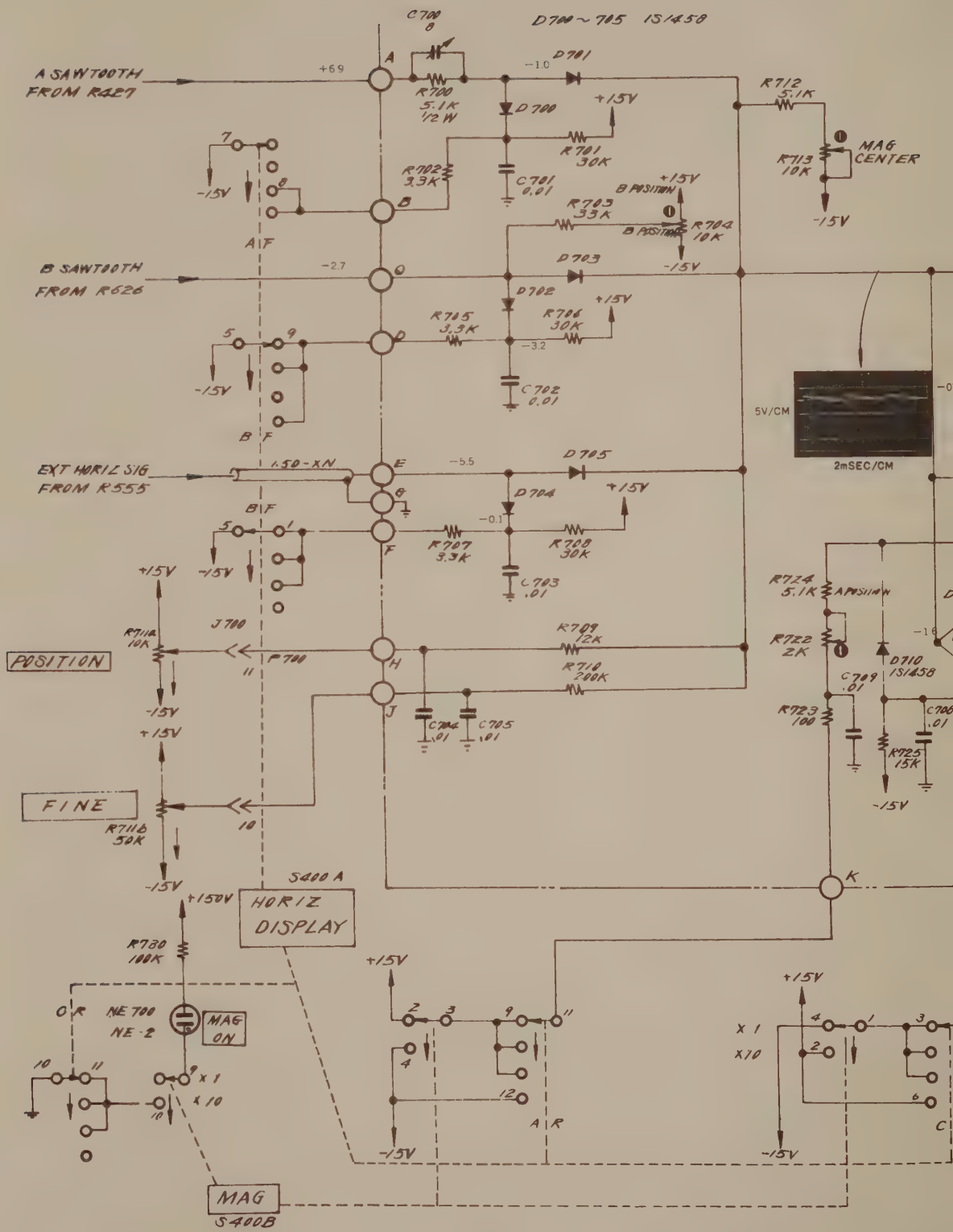
HORIZ PREAMPLIFIER ➡



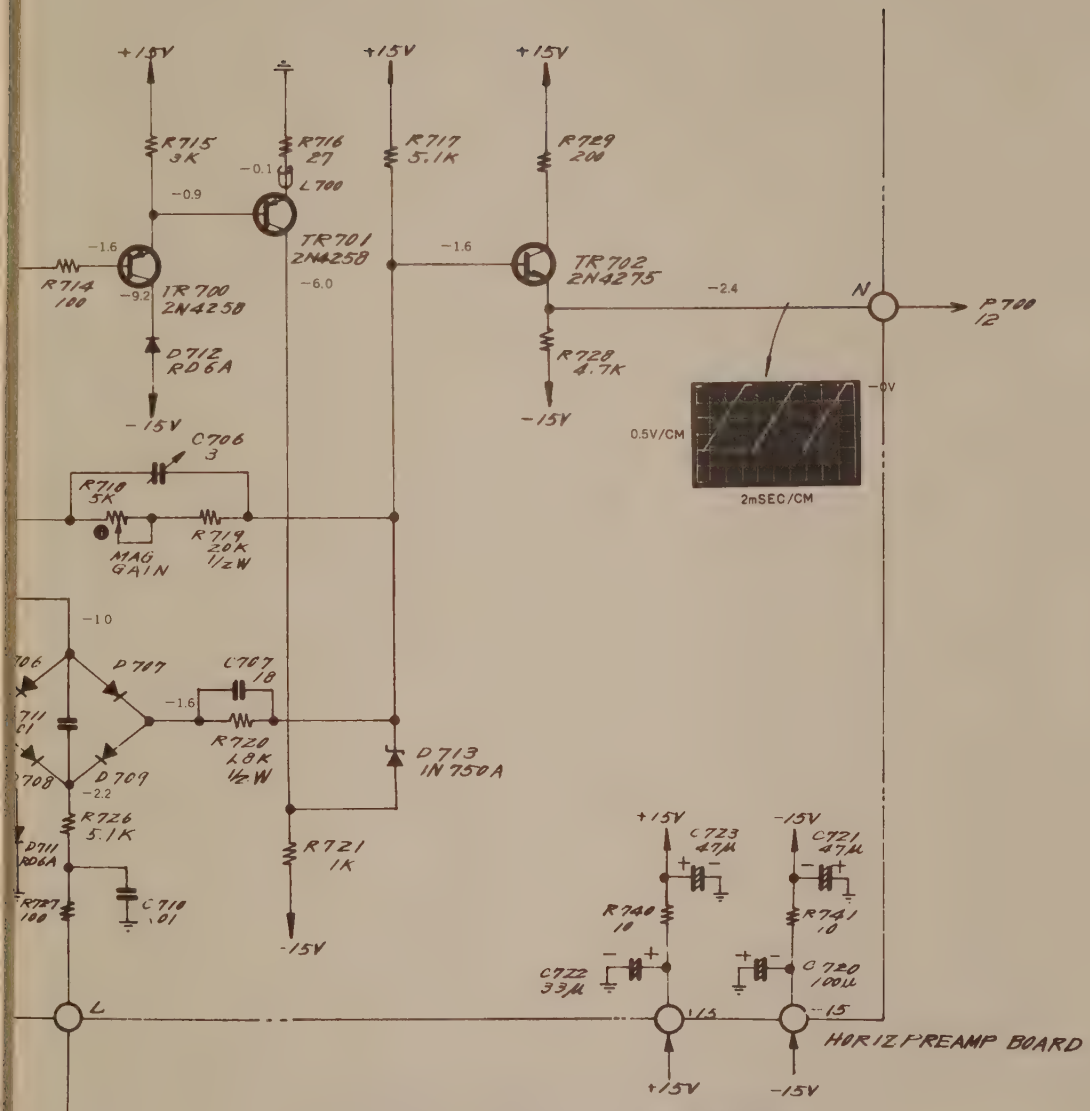
VOLTAGE READING CONDITIONS

HORIZ DISPLAY ..... DLY'D (B)
DLY'D (B) MODE ..... TRIG'D
B TIME/CM ..... 0.1 mSEC
B TIME/CM VARIABLE ..... CALIB

TIMING SWITCH "B"


A SAWTOOTH FROM R427
B SAWTOOTH FROM R626
EXT HORIZ SIG FROM R555
POSITION
FINE
HORIZ DISPLAY
S400A
MAG
S400B
MAG ON
MAG CENTER
A POSITION
B POSITION
5V/CM
2mSEC/CM
D700~705 1S1458
D710 1S1458
C700 8
R700 5.1K 1/2W
R701 30K
R702 3.3K
R703 33K
R704 10K
R705 3.3K
R706 30K
R707 3.3K
R708 30K
R709 12K
R710 200K
R711A 10K
R711B 50K
R712 5.1K
R713 10K
R722 2K
R723 100
R724 5.1K
R725 15K
R730 100K
C701 0.01
C702 0.01
C703 .01
C704 .01
C705 .01
C706 .01
C709 .01
J700
P700
NE 700
NE-2
+15V
-15V
+150V
+6.9
-1.0
-2.7
-3.2
-5.5
-0.1
-16

HORIZ MAINAMPLIFIER ➡

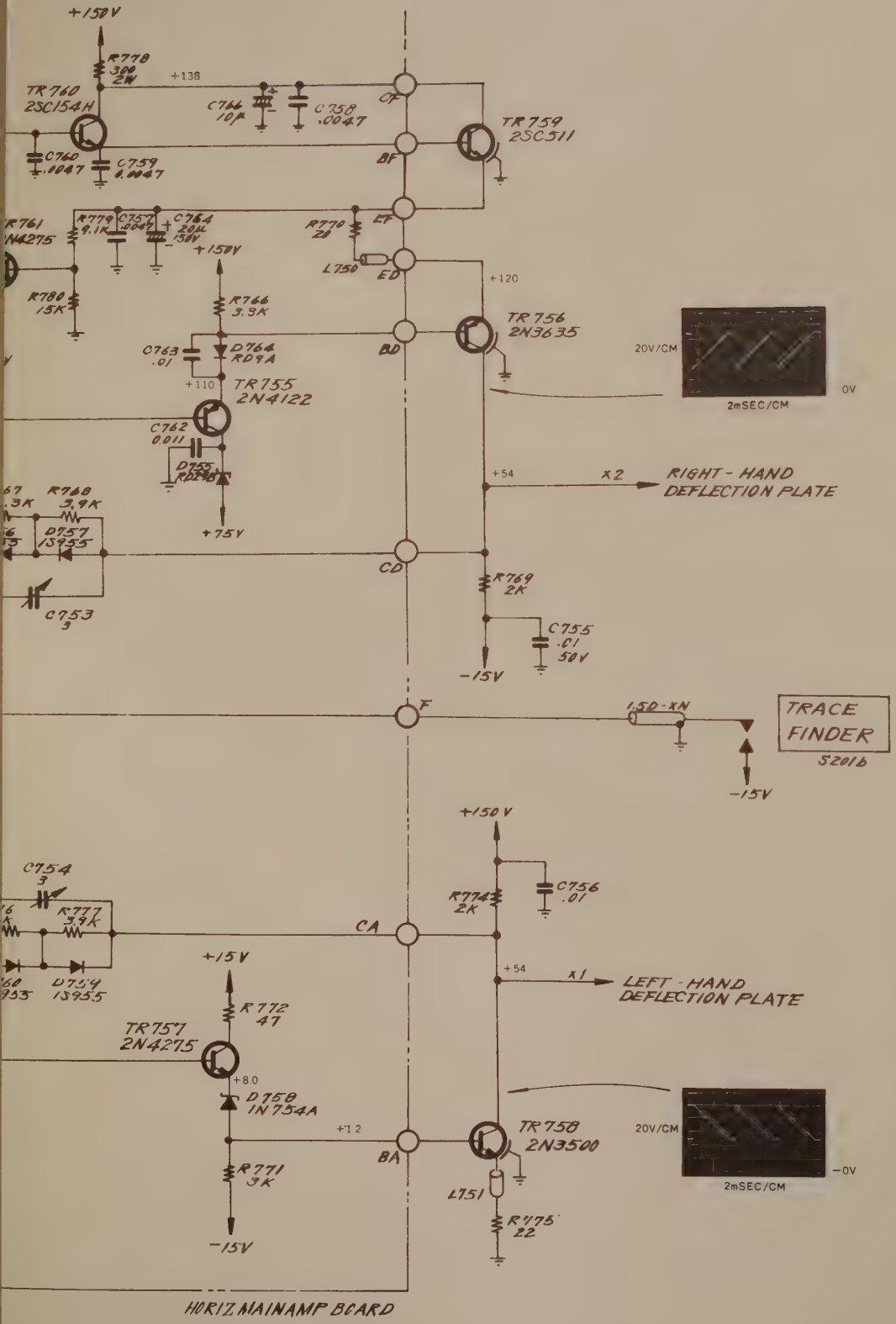


VOLTAGE & WAVEFORM READING CONDITIONS

HORIZ DISPLAY	A
MAG	X 1
POSITION	MIDRANGE
FINE	MIDRANGE
A TIME/CM	0.5 mSEC

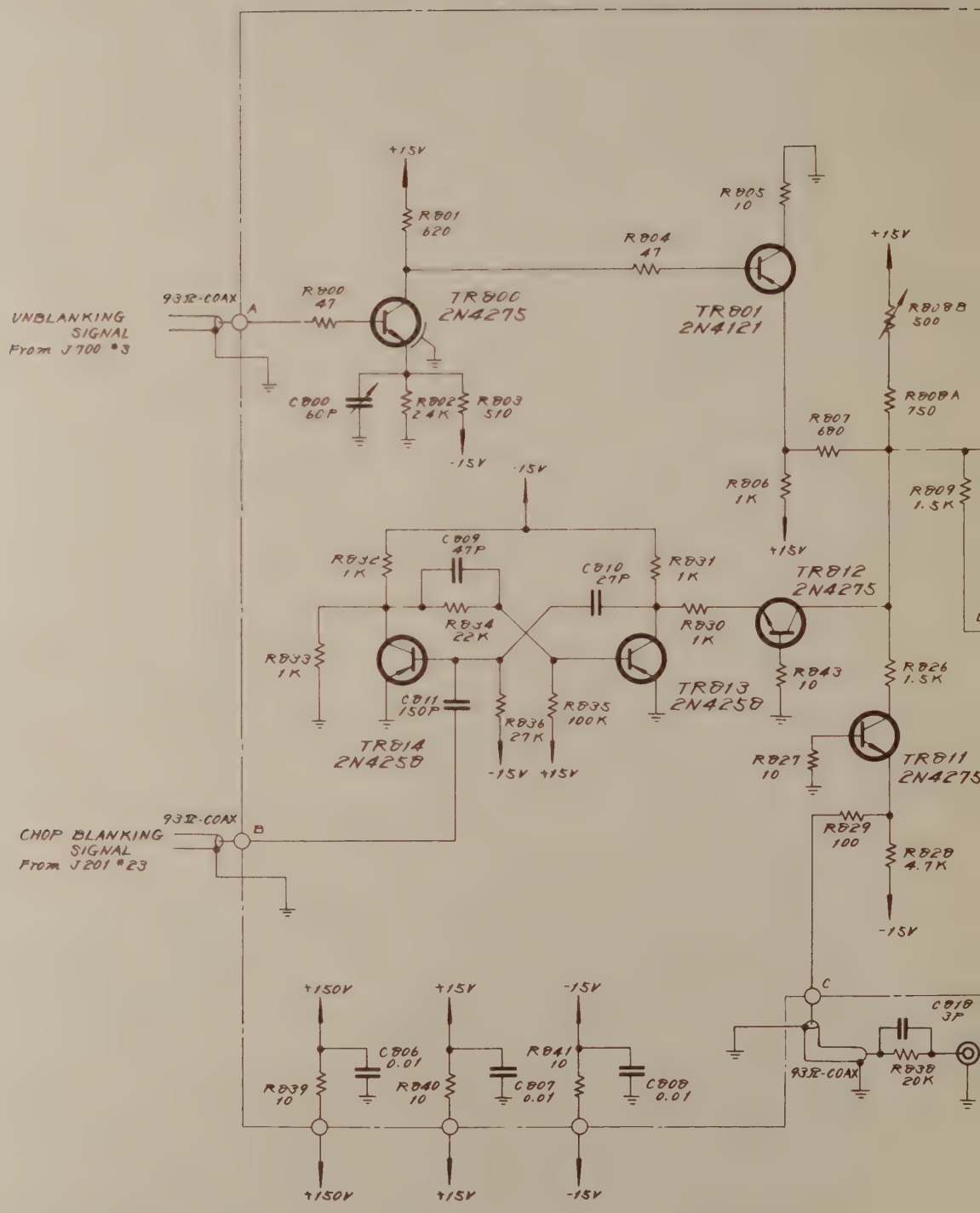
A
A INT BY B
DLY'D (B)
EXT HORIZ

HORIZ PREAMPLIFIER

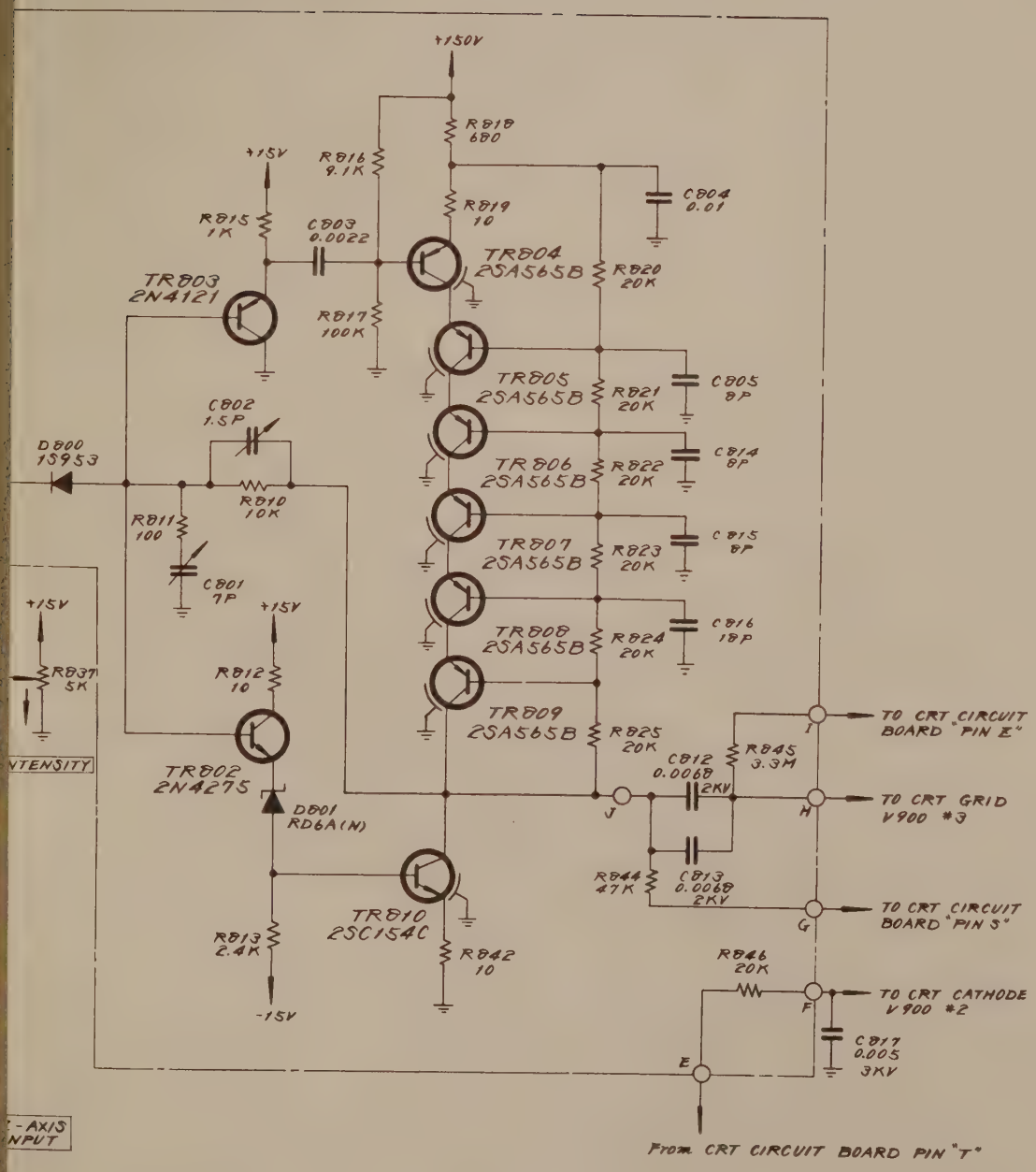


HORIZ MAINAMPLIFIER

Z AXIS AMPLIFIER ➡


+15V
RB01 620
RB05 10
RB04 47
+15V
93Ω-COAX
A
RB00 47
TRB00 2N4275
TRB01 2N4121
RB08B 500
UNBLANKING SIGNAL From J700 #3
CB00 60P
RB02 2.4K
RB03 510
RB08A 750
RB07 680
-15V
-15V
RB06 1K
+15V
RB09 1.5K
CB09 47P
RB32 1K
CB10 27P
RB31 1K
TRB12 2N4275
RB34 22K
RB30 1K
RB33 1K
RB43 10
RB26 1.5K
CB11 150P
RB36 27K
RB35 100K
TRB13 2N4258
TRB14 2N4258
-15V +15V
RB27 10
TRB11 2N4275
93Ω-COAX
B
CHOP BLANKING SIGNAL From J201 #23
RB29 100
RB28 4.7K
-15V
+150V
+15V
-15V
C
CB18 3P
CB06 0.01
RB41 10
RB39 10
RB40 10
CB07 0.01
CB08 0.01
93Ω-COAX
RB38 20K
+150V
+15V
-15V

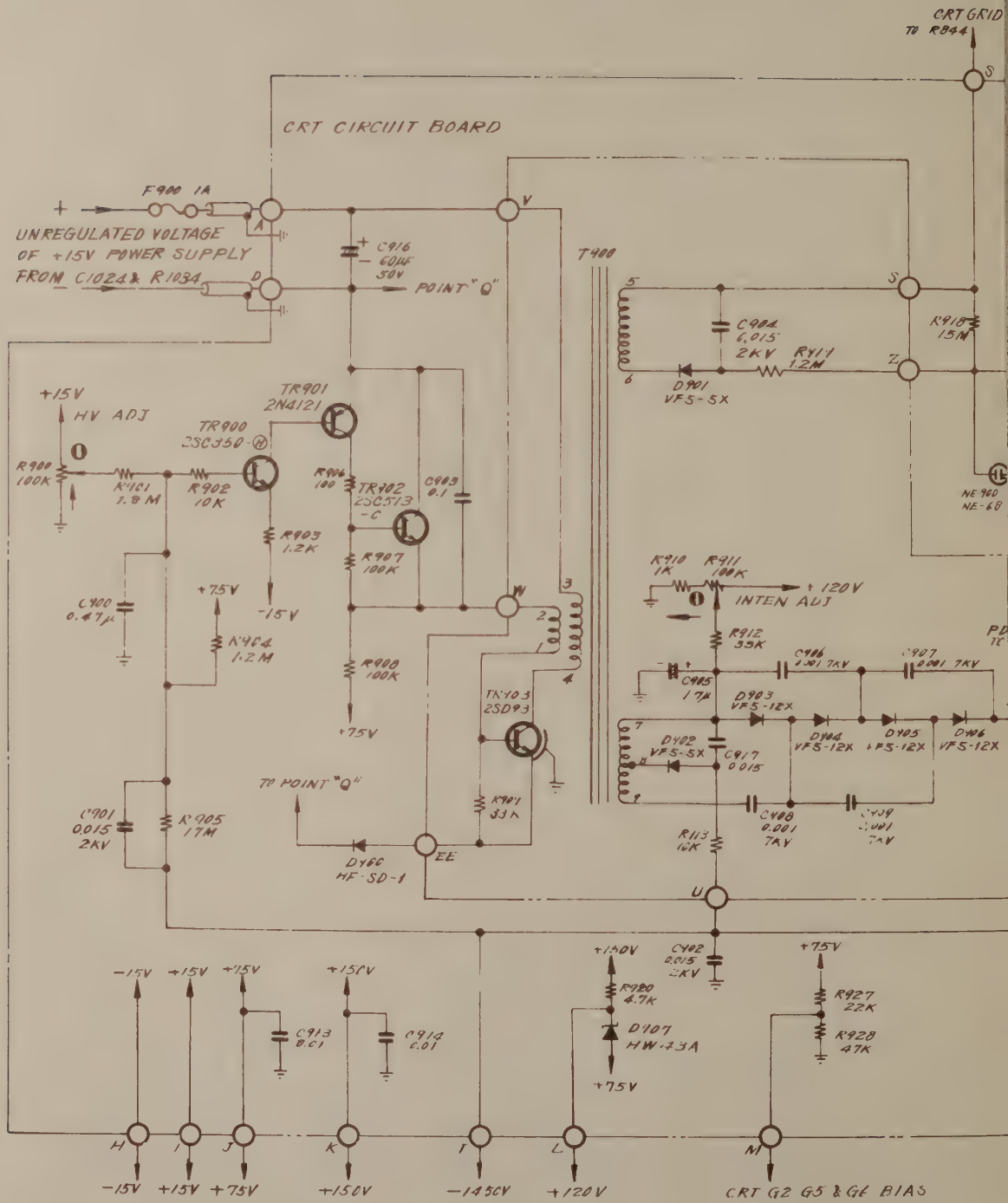
CRT CIRCUIT ➡



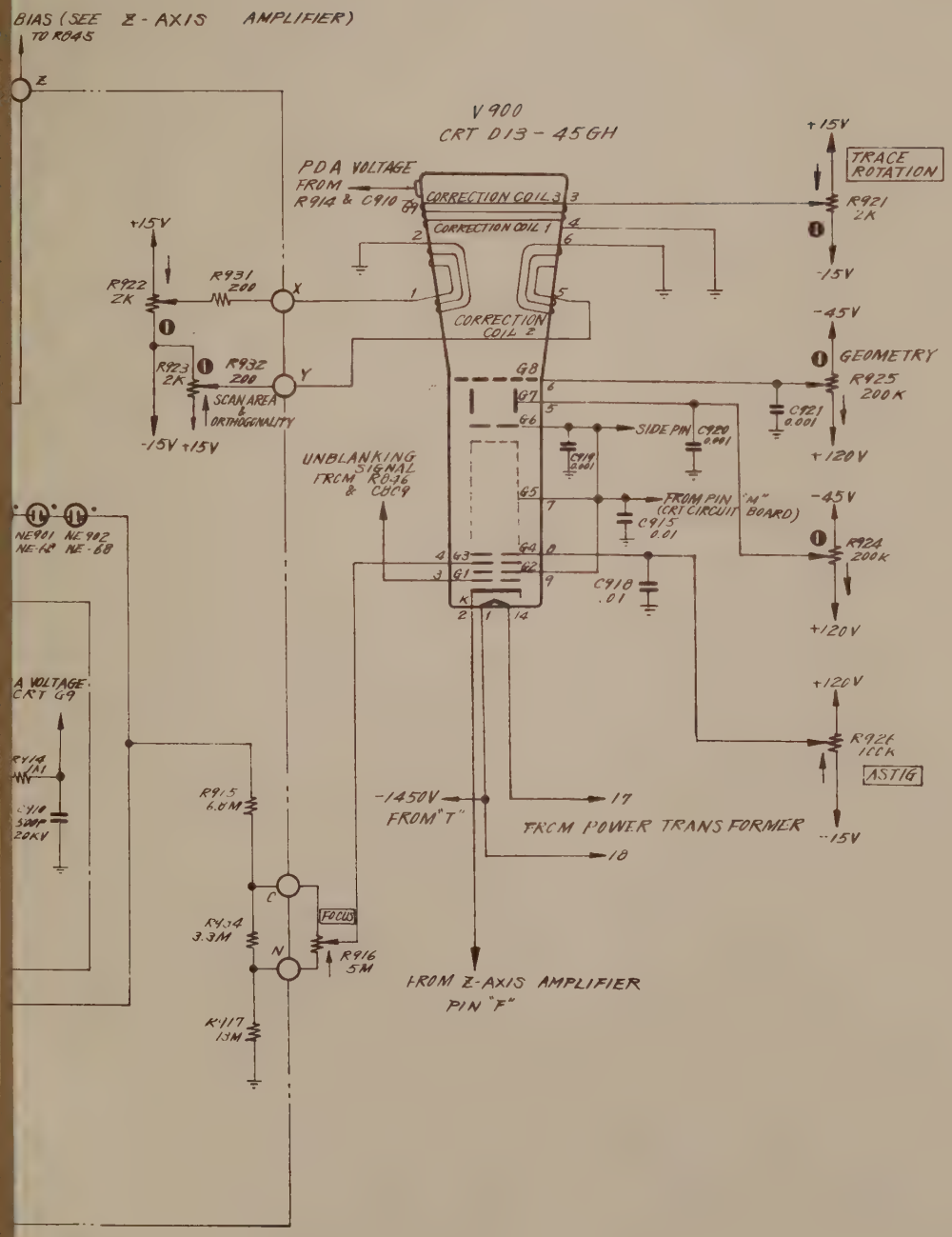
Z AXIS AMPLIFIER

K—605225

CRT CIRCUIT ➡

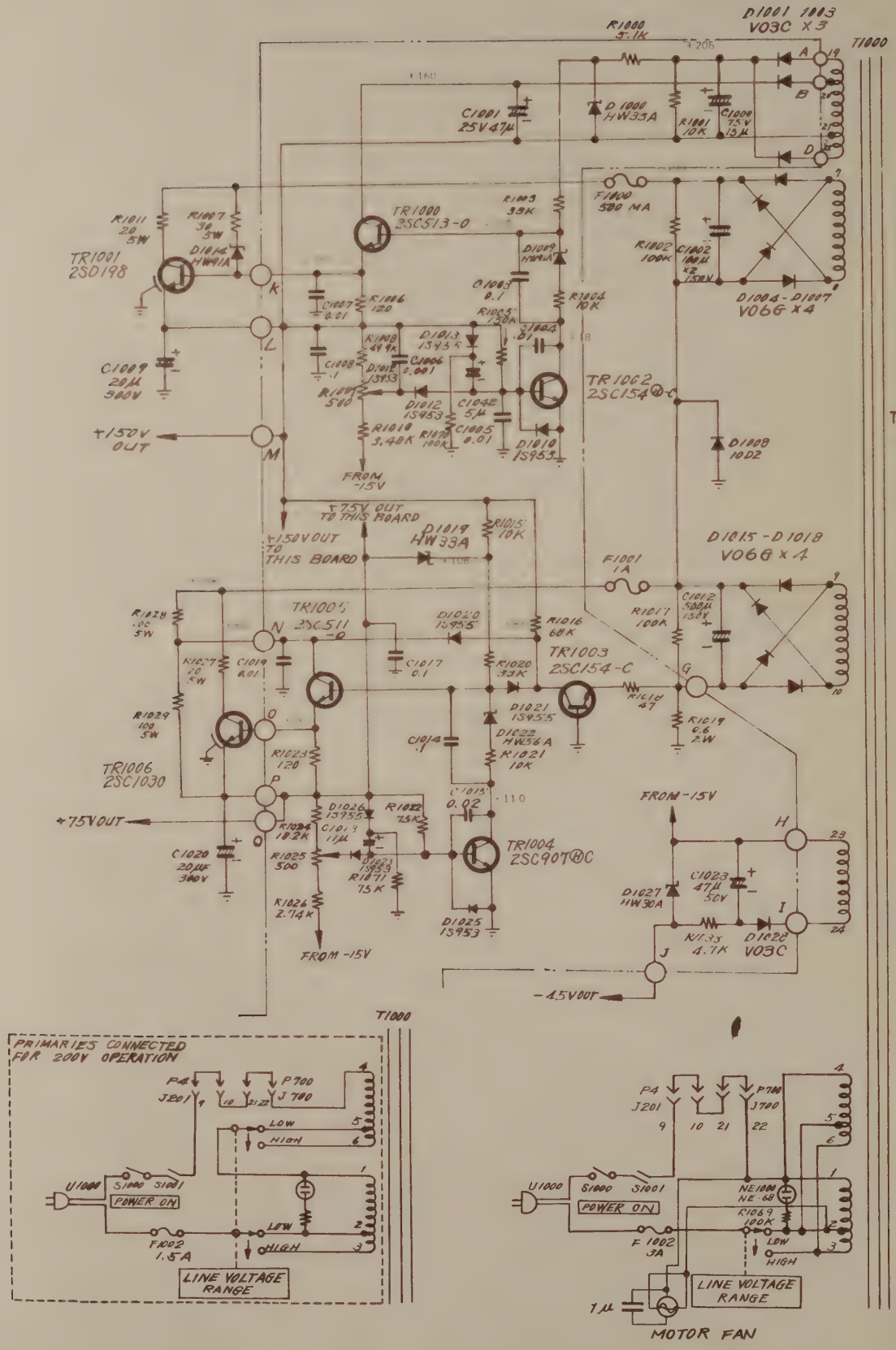

CRT GRID
TO R844
CRT CIRCUIT BOARD
F900 1A
UNREGULATED VOLTAGE
OF +15V POWER SUPPLY
FROM C1024 & R1034
C916
60UF
50V
POINT "Q"
T900
C904
0.015
2KV
R911
1.2M
R918
15M
D901
VF5-5X
NE 960
NE-68
+15V
HV ADJ
TR901
2N4121
TR900
2SC350-W
R900
100K
R901
1.8M
R902
10K
R906
100
TR902
2SC513
-C
C903
0.1
R903
1.2K
R907
100K
C900
0.47μ
+75V
-15V
R904
1.2M
R908
100K
TR903
2SD93
R910
1K
R911
100K
+120V
INTEN ADJ
R912
33K
C906
0.001 7KV
C907
0.001 7KV
C905
17M
D903
VF5-12X
D904
VF5-12X
D905
VF5-12X
D906
VF5-12X
D902
VF5-5X
C917
0.015
C908
0.001
7KV
C909
0.001
7KV
R913
10K
R909
33K
TO POINT "Q"
C901
0.015
2KV
R905
17M
D906
HF-SD-1
-15V
+15V
+75V
+150V
C913
0.01
C914
0.01
C902
0.015
2KV
R920
4.7K
D907
HW-73A
R927
22K
R928
47K
H
I
J
K
L
M
-15V
+15V
+75V
+150V
-145CV
+120V
CRT G2 G5 & G6 BIAS

LOW VOLTAGE
POWER SUPPLY ➡

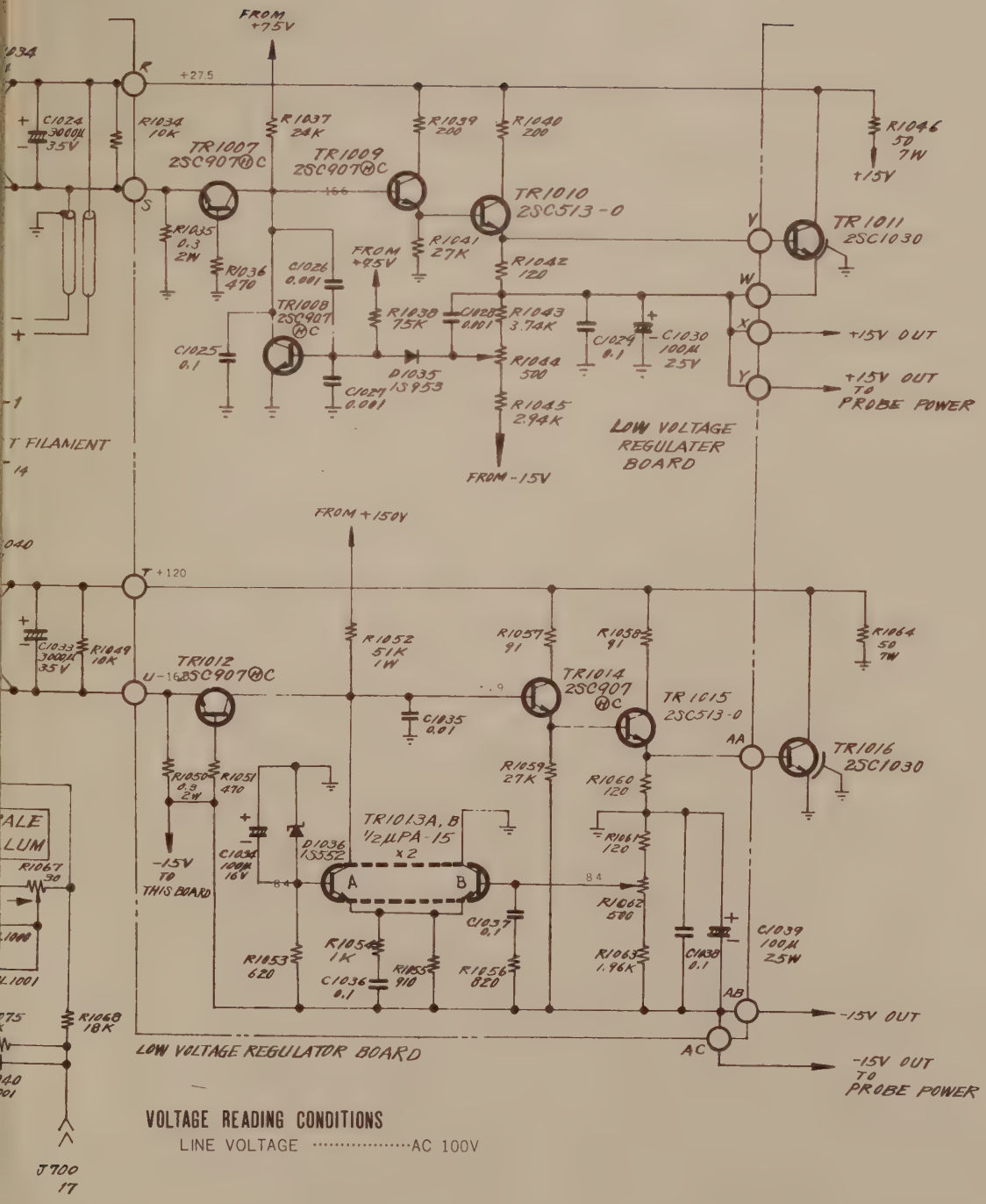

BIAS (SEE Z-AXIS AMPLIFIER)
TO R845
Z
V900
CRT D13-45GH
PDA VOLTAGE
FROM
R914 & C910
CORRECTION COIL 3
CORRECTION COIL 1
CORRECTION COIL 2
+15V
R922 2K
R931 200
R923 2K
R932 200
SCAN AREA & ORTHOGONALITY
-15V +15V
X
Y
TRACE ROTATION
R921 2K
-15V
-45V
GEOMETRY
R925 200K
+120V
C921 0.001
SIDE PIN
C920 0.001
C919 0.001
UNBLANKING SIGNAL FROM R836 & C809
FROM PIN "M" (CRT CIRCUIT BOARD)
C915 0.01
R924 200K
C918 .01
NE901 NE-2R
NE902 NE-2R
A VOLTAGE CRT G9
R914 1A1
C910 5000pf 20KV
R915 6.8M
R934 3.3M
R916 5M
R917 13M
FOCUS
ASTIG
R926 100K
-1450V FROM "T"
17
18
FROM POWER TRANSFORMER
FROM Z-AXIS AMPLIFIER PIN "F"

CRT CIRCUIT

LOW VOLTAGE
POWER SUPPLY


D1001 1003
V03C X3
T1000
R1000
5.1K
C1001
25V 47μ
D 1000
HW33A
R1001
10K
C1000
75V
15μ
F1000
500 MA
R1003
33K
TR1000
2SC513-O
R1011
20
5W
R1007
30
5W
TR1001
2SD198
D1014
HW41A
C1007
0.01
R1006
120
C1009
20μ
300V
+150V
OUT
R1008
4.7K
C1006
0.001
D1013
1S953
D1011
1S953
R1009
500
D1012
1S953
C1042
5μ
R1010
3.48K
R1005
150K
C1005
0.01
C1004
.01
D1010
1S953
FROM
-15V
R1004
10K
C1003
0.1
D1009
HW41A
R1002
100K
C1002
100μ
K2
150V
D1004 - D1007
V06G X4
TR1002
2SC154
D1008
10D2
To CRT CIRCUIT
+150V OUT
TO
THIS BOARD
+75V OUT
TO THIS BOARD
D1019
HW33A
R1015
10K
D1015 - D1018
V06G X4
F1001
1A
R1028
.68
5W
TR1005
2SC511
-O
D1020
1S955
R1016
68K
R1017
100K
C1012
500μ
150V
TR1003
2SC154-C
R1027
20
5W
C1019
0.01
C1017
0.1
R1020
33K
R1018
47
R1029
100
5W
D1021
1S955
D1022
HW56A
R1021
10K
R1019
0.6
2W
C1014
.1
TR1006
2SC1030
R1023
120
C1015
0.02
FROM -15V
+75V OUT
D1026
1S953
R1022
75K
C1013
1μ
TR1004
2SC90T-C
C1020
20μF
300V
R1025
500
D1023
1S953
R1071
75K
R1024
18.2K
R1026
2.74K
D1025
1S953
FROM -15V
C1023
47μ
50V
D1027
HW30A
R1133
4.7K
D1028
V03C
-45V OUT
T1000
PRIMARIES CONNECTED
FOR 200V OPERATION
P4
J201
P700
J700
LOW
HIGH
U1000
S1000
S1001
POWER ON
F1002
1.5A
LOW
HIGH
LINE VOLTAGE
RANGE
P4
J201
P700
J700
U1000
S1000
S1001
POWER ON
NE100M
NE-68
R1069
100K
F 1002
3A
LOW
HIGH
LINE VOLTAGE
RANGE
1μ
MOTOR FAN

CALIBRATOR ➡

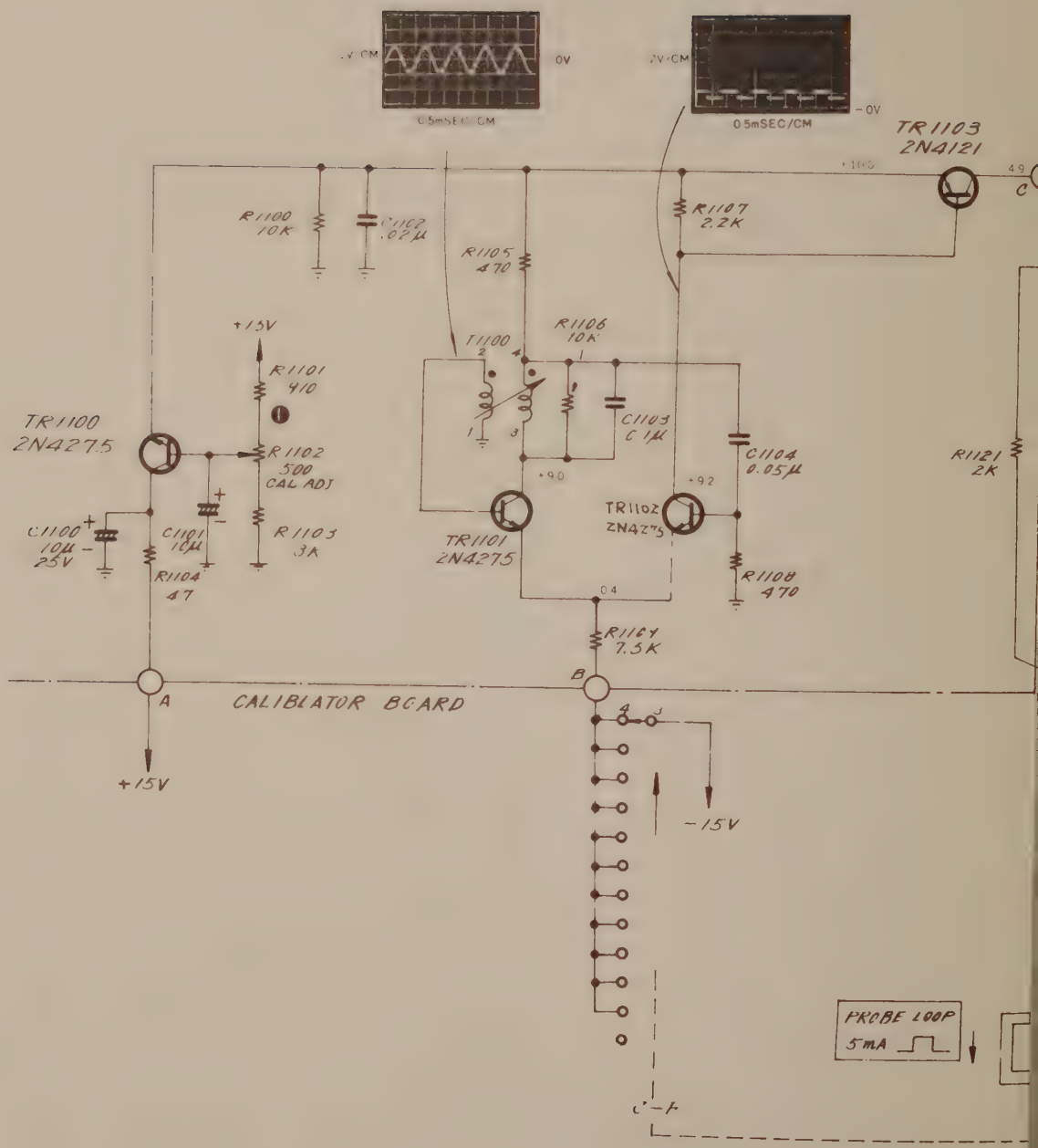


VOLTAGE READING CONDITIONS

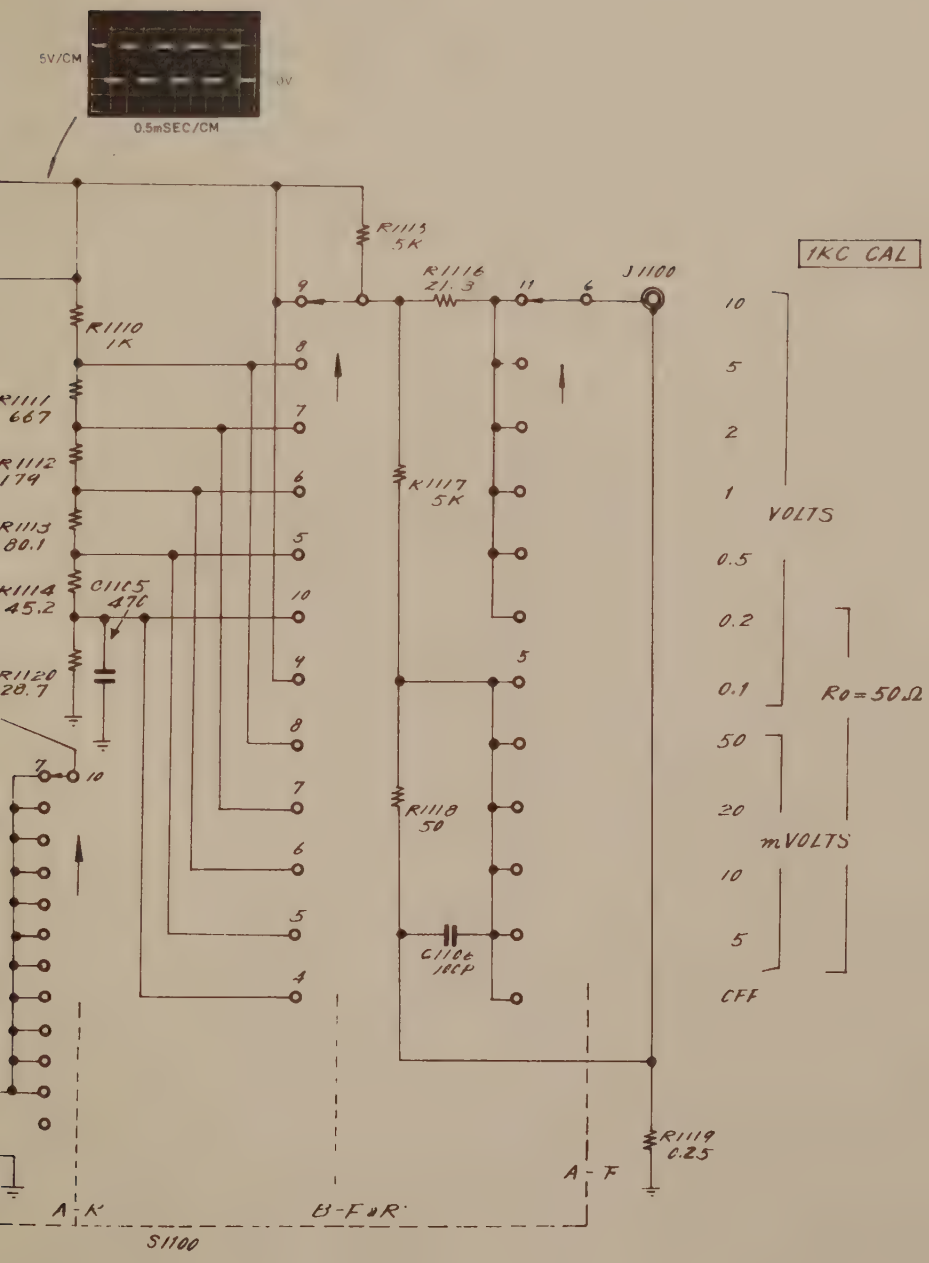
LINE VOLTAGE ·····AC 100V

LOW VOLTAGE POWER SUPPLY

CALIBRATOR


.5V CM
0V
0.5mSEC/CM
2V/CM
-0V
0.5mSEC/CM
TR1103
2N4121
R1100
10K
C1102
.02μ
R1105
470
R1107
2.2K
+15V
R1101
410
T1100
R1106
10K
TR1100
2N4275
R1102
500
CAL ADJ
C1103
C 1μ
C1104
0.05μ
R1121
2K
C1100
10μ
25V
C1101
10μ
R1103
3K
R1104
47
TR1101
2N4275
TR1102
2N4275
R1108
470
R1109
7.5K
A
B
CALIBLATOR BOARD
+15V
-15V
PROBE LOOP
5mA

PLUG-IN CONNECTOR ➡

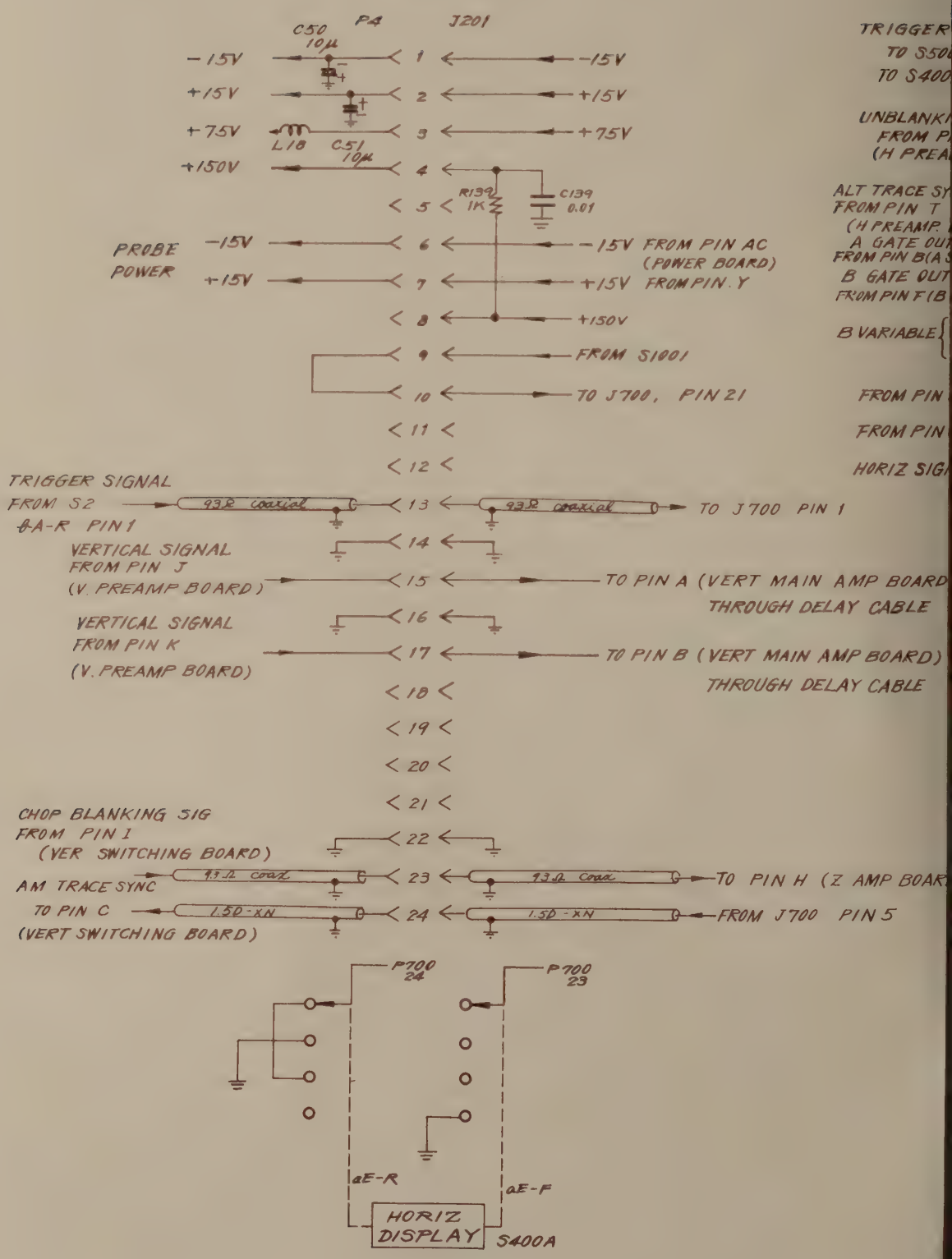


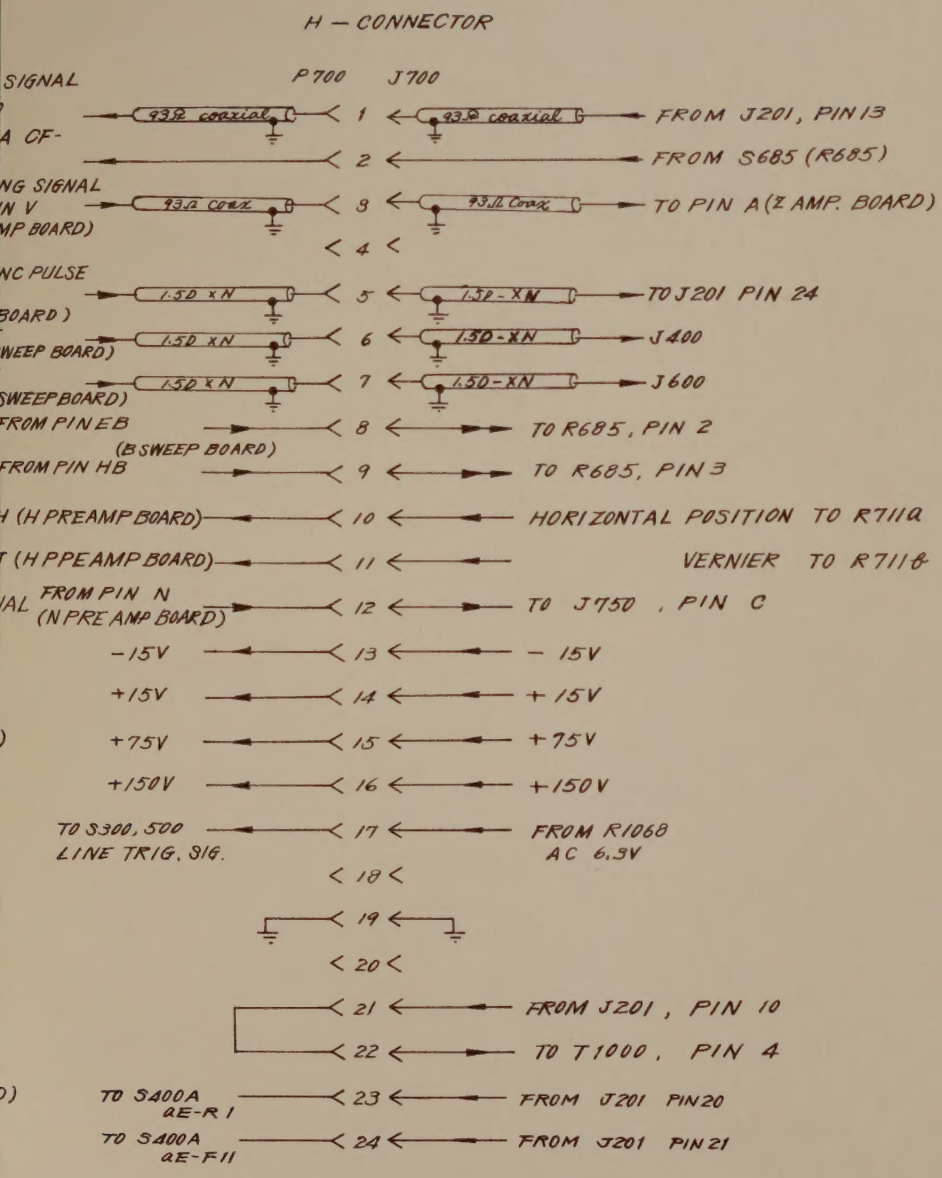
CALIBRATOR

K—605095

PLUG-IN CONNECTOR ➡

V - CONNECTOR


P4
J201
C50 10μ
-15V
+15V
+75V
+150V
L18
C51 10μ
R139 1K
C139 0.01
PROBE POWER
-15V FROM PIN AC (POWER BOARD)
+15V FROM PIN Y
+150V
FROM S1001
TO J700, PIN 21
TRIGGER SIGNAL FROM S2 6A-R PIN 1
93Ω coaxial
TO J700 PIN 1
VERTICAL SIGNAL FROM PIN J (V. PREAMP BOARD)
TO PIN A (VERT MAIN AMP BOARD) THROUGH DELAY CABLE
VERTICAL SIGNAL FROM PIN K (V. PREAMP BOARD)
TO PIN B (VERT MAIN AMP BOARD) THROUGH DELAY CABLE
CHOP BLANKING SIG FROM PIN I (VER SWITCHING BOARD)
AM TRACE SYNC TO PIN C (VERT SWITCHING BOARD)
93Ω coax
TO PIN H (Z AMP BOAR
1.5D-XN
FROM J700 PIN 5
P700 24
P700 23
aE-R
aE-F
HORIZ DISPLAY
S400A
TRIGGER
TO S50
TO S400
UNBLANKI
FROM P
(H PREA
ALT TRACE SY
FROM PIN T
(H PREAMP.
A GATE OUT
FROM PIN B(A S
B GATE OUT
FROM PIN F(B
B VARIABLE
FROM PIN
FROM PIN
HORIZ SIG



PLUG-IN CONNECTOR

IWATSU

54288